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J. S. Gray
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FIFTH ANNUAL REPORT

OF THE

BOSTON TRANSIT COMMISSION,

FOR THE YEAR ENDING

AUGUST 15, 1899.

FROM

THE BOSTON TRANSIT COMMISSION,
20 Beacon Street.

GEORGE G. CROCKER, *Chairman,*

CHARLES H. DALTON,

GEORGE F. SWAIN,

THOMAS J. GARGAN,

HORACE G. ALLEN,

Commissioners.

HOWARD A. CARSON,

B. LEIGHTON BEAL,

Chief Engineer.

Secretary.

1899.

FIFTH ANNUAL REPORT

OF THE

BOSTON TRANSIT COMMISSION,

FOR THE YEAR ENDING

AUGUST 15, 1899.



BOSTON :

ROCKWELL AND CHURCHILL PRESS.

1899.

Feb. 1, 1932

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BOSTON TRANSIT COMMISSION.

20 BEACON STREET,
BOSTON, Aug. 15, 1899.

TO THE CITY COUNCIL OF THE CITY OF BOSTON :

In compliance with Statutes of 1894, chapter 548, section 24, the report of the Boston Transit Commission for the year ending Aug. 15, 1899, is respectfully submitted.

EXTENSION OF TERM OF THE COMMISSION.

The term for which the Commission was originally appointed expired July 2, 1899. By act of the Legislature of 1899, chapter 375, the term was extended for three years from the first day of July, 1899. The Commission on August 3 organized for the extended term by the choice of George G. Crocker as Chairman, Howard A. Carson as Chief Engineer, and B. Leighton Beal as Secretary.

COMPLETION OF THE SUBWAY.

At the date of the fourth annual report the subway as originally planned was completed with the exception of minor details of interior finish. Sept. 3, 1898, that portion of the subway not already in use, namely, from Park-street station to the northern terminal, was opened to the public.

ESTIMATED COST OF THE SUBWAY.

The estimated cost of the subway as originally planned in 1894 was \$5,000,000. Its net cost to the date of this report is \$4,141,896.46. The increase of this amount will be small. The total cost probably will not exceed \$4,200,000. There has been expended up to August 15, 1899, on account of the alterations required by the Act of 1897 to adapt the subway to the use of the Boston Elevated Railway Company, \$190,802.24, of which \$103,607.40 was for real estate. All the alterations which were in progress at the time of the last report have been completed.

TREMONT-STREET TRACKS.

The Act of 1894 requires that the Commission "on or before the completion of" the subway "shall order all tracks to be removed from Tremont street between Boylston street and Scollay square, and from Boylston street between Tremont street and Park square." In compliance therewith on Sept. 6, 1898, the following votes were passed:

Voted, That in accordance with the requirements of Statutes 1894, chapter 548, section 35, all surface tracks on Tremont street between Boylston street and Scollay square and on Boylston street between Park square and Tremont street are hereby ordered to be removed.

Voted, That copies of the foregoing order be forwarded to the West End Street Railway Company and the Boston Elevated Railway Company.

Pursuant to the foregoing order, the tracks were removed in the months of October and November from the localities named.

By the terms of the lease of the subway to the West End Street Railway Company "the party of the second part agrees that it will make no claim against the party of the first part for any damage for removing upon the order of the Commission its surface tracks from Tremont street between Boylston street and Scollay square and from Boylston street between Park square and Tremont street and such other tracks as the Commission may order to be removed under the authority of the aforesaid acts provided that during the term of this contract the right to lay, maintain, and use tracks on the locations from which the tracks are so removed, be not granted nor permitted to any other person or corporation for street railway purposes and the party of the second part agrees at its own expense to restore and leave in good condition the pavement of that portion of the streets occupied by the tracks so removed."

HAYMARKET SQUARE PROPERTY.

At the date of the last annual report negotiations had been begun with His Honor the Mayor looking to the release to the city of such portions of the property taken in 1894 from the Boston & Maine Railroad, being the old station property, as were not needed for subway purposes. Messrs. John C. Cobb on behalf of the city, and Frederic H. Viaux for the Boston Elevated Railway Company, had been selected as appraisers. Subsequently these two gentlemen agreed upon Mr. Robert Codman as a third appraiser, and on Sept. 30, 1898, they reported as follows:

OFFICES OF

ROBERT CODMAN . . .	27 Kilby Street.
JOHN C. COBB . . .	66 State Street.
FREDERIC H. VIAUX . . .	53 State Street.

BOSTON, Sept. 30, 1898.

GENTLEMEN: We have considered the value of the land of the city of Boston bounded by Canal, Travers, and Haverhill streets and Haymarket square, Boston, subject in part to certain subway easements and as shown on a copy of a plan furnished us by the Boston Transit Commission, numbered 4189, and signed H. A. Carson, Chief Engineer, and we find their present worth to be according to our judgment, in total, five hundred and seventy-five thousand dollars (\$575,000). The value of the right to use subway walls for foundation purposes is included. The strip on Canal street in two pieces, containing together, according to said plan, eight thousand four hundred and fifty-six (8,456) square feet, is included in this valuation at the price agreed upon between you, viz.: seven dollars (\$7) per square foot, equal to \$59,192.

The right to build over the strip of land on Haverhill street, containing, according to said plan, sixteen thousand nine hundred and twenty-five (16,925) square feet, subject to subway easements, is included in the total valuation and is estimated by us as having a value of forty-two thousand dollars (\$42,000).

Respectfully yours,

(Signed)

ROBERT CODMAN,
JOHN C. COBB,
FREDERIC H. VIAUX.

To the

BOSTON TRANSIT COMMISSION,
HON. GEORGE G. CROCKER, *Chairman*.
BOSTON ELEVATED RAILROAD COMPANY,
COL. WILLIAM A. GASTON, *President*.

This report was submitted to His Honor the Mayor, who replied as follows:

MAYOR'S OFFICE, CITY HALL, BOSTON, Oct. 7, 1898.

To the Boston Transit Commissioners:

I received from you copy of award of Robert Codman, John C. Cobb, and Frederic H. Viaux, referees, fixing the price for the purpose of transfer to the city of certain land bounded by Canal, Travers, and Haverhill streets and Haymarket square. As the right to build over the subway incline is separately appraised at the sum of \$42,000, I assume that this amount may be deducted from the total sum of \$575,000, if the city does not care to acquire it, and I have come to the conclusion that it is not desirable that the city should take such right, and should, therefore, like to have this amount deducted. I understand that there are 11,833 feet included in the lands of the proposed widening on Canal street, between Travers and Causeway streets, not included in the award of the referees, which would come to \$82,831, making a total of \$657,831, which would be reduced to \$615,831 by deducting the right to build over the subway incline. In order to have a round number I would suggest that you call this \$615,000, and settle the matter on that basis.

I shall be ready to approve any votes that may be needed to carry this arrangement into effect as soon as they have been passed by your Commissioners.

Yours respectfully,

(Signed)

JOSIAH QUINCY,
Mayor.

Thereupon on Oct. 11, 1898, the following vote was passed :

Voted, That in the opinion of this Commission the value of the property to be transferred to the city of Boston for a market or other public purpose under Statutes 1897, chapter 347, is \$616,000.

This sum has been credited to the subway account by the City Treasurer and has reduced the net cost of the subway by that amount.

In accordance with chapter 347 of the Acts of 1897, the amount of the bonds, \$7,000,000, originally placed at the disposal of the Commission for the construction of the subway and other purposes, is reduced by a like sum.

SHELTER AT THE NORTHERN TERMINAL.

As the arrangement of tracks of the Boston Elevated Railway Company in the open space at Causeway, Canal, and Haverhill streets is only temporary, it was not intended at first to erect any structure there in the nature of a shelter, but when it became apparent that the temporary condition of matters would last for two or three years it was realized that some sort of protection for the public would be needed. After consultation with the Boston Elevated Railway Company, that corporation requested that a shelter be erected by this Commission and be considered as an adjunct of the subway. Accordingly on October 27 it was voted to erect a shelter which should be of the simplest form to accord with the temporary nature of its use. Its cost was about \$4,900.

TRAVERS STREET.

On August 30, 1898, the following was passed :

Voted, That that portion of Travers street between Canal street and Haverhill street which has not been discontinued by vote of July 12, 1898, under the provisions of Statutes 1897, chapter 500, be discontinued under Statutes 1894, chapter 548.

This closed the whole of Travers street between the streets named. In July last the following communication was received :

CITY OF BOSTON.

IN BOARD OF ESTIMATE AND APPORTIONMENT, July 12, 1899.

Voted, That the Boston Transit Commission be requested to inform the Board of Estimate and Apportionment as to whether in their opinion they have a right under the law to construct a tunnel under the tracks of the Boston Elevated Railway Company at Travers street for foot-pas-

sage such as is proposed, and whether, if they have such right, they would be willing to construct such a tunnel.

A true copy.

Attest:

(Signed)

J. A. MCKIBBEN,

Assistant Secretary.

To this the Commission replied as follows :

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, July 18, 1899.

LAURENCE MINOT, Esq., *Secretary, Board of Estimate and Apportionment* :

DEAR SIR: At a meeting of the Boston Transit Commission held this day I was requested to suggest to your Board the advisability of its obtaining the opinion of the Corporation Counsel upon the question of the rights of this Commission to construct a tunnel for foot-passengers under the tracks of the Boston Elevated Railway Company at Travers street, the expense thereof to be charged to the cost of the construction of the subway. If in the opinion of the Corporation Counsel such right exists, this Commission can then take up the question of the advisability of such construction.

(Signed)

Yours truly,

H. G. ALLEN,

Chairman pro tem.

Subsequently the Corporation Counsel rendered an opinion that the Commission could use the funds at its disposal for such purpose.

At the date of this report final action upon this matter has not been taken.

TRAFFIC STATISTICS.

Prior to September, 1897, when all the Tremont-street car traffic ran on the surface, the utmost limit of capacity of the surface tracks was found to be about 200 cars per hour each way. Whenever this limit was approached congestion and blockades resulted. The cars in unbroken procession moved with a slowness which was vexatious and which was aggravated by stop after stop of uncertain duration. The rate of progress was often not more than two miles per hour. In October, 1898, one month after the completed transfer of the surface traffic to the subway, the number of cars passing freely each way at the same point within the subway in the hours of greatest traffic was 282, the rate of speed, including stops, being between seven and eight miles per hour. This meant that the cars between the Public-Garden entrance and the Park-street station moved on a fixed schedule time of four minutes in the subway instead of an uncertain time on the surface varying from 10 to 20 minutes.

At the date of this report the subway as a whole has been in use a little over eleven months. Statistics for the full year cannot, therefore, be given. It is, however, believed to be a safe estimate that the use of the subway for the first eleven months has been at the rate of at least 50,000,000 passengers per year. The Boston Elevated Railway and the Lynn & Boston Railway together operate in Boston and vicinity over 400 miles of track, reckoned as single track, and in the year 1897 to 1898 carried in round numbers 200,000,000 passengers. The trackage in the subway is one-eightieth of this total trackage (5 miles out of 400), and yet it appears as above that of the total number of passengers carried on all the 400 miles of track of these two great roads, about one out of four passes through some portion of the subway.

Park-street Station.

The subway act of 1894 imposed such stringent limitations as to encroachment upon the Common and upon Tremont street that in the following year the Commission was forced to ask that the boundaries which had been fixed should be enlarged. It was a question whether the Legislature would not prefer to repeal the act, and a bill for that purpose was passed to a third reading in the House of Representatives. Finally a slight enlargement of the boundaries was granted, but only upon a positive assurance that none of the old elms between West street and the south line of St. Paul's Church should be disturbed. Within these limitations the Commission, in planning the Park-street station, used every available inch of space.

The traffic at the Park-street station was expected to be, and is, greater than that at any other station within the subway. The number of people who pass up and down the stairways to this station is about twice as great as that using the Scollay-square station, which is the next largest in point of traffic. The Park-street station, moreover, is used as the general transfer station for the subway. This transfer traffic does not use the stairways, but it increases the use of the platforms by about 42 per cent. From statistics furnished by the Boston Elevated Railway Company, it appears that during the first eleven months of the operation of the subway as a whole the passenger traffic on the two island platforms at this station, which platforms have together an area of 15,197 square feet, a little over one-third of an acre, has been at the rate of 27,400,000 per year. In amount of passenger traffic the Park-street station ranks among the largest in the world.

Station.	Total number of passengers per annum.
St. Louis Union Station, St. Louis	8,000,000
Grand Central Station, New York City	14,000,000
South Union Station, Boston	21,000,000
North Union Station, Boston	23,108,384
Broad-street Station of the North London Railroad	27,000,000
Park-street Station of the Boston Subway	27,400,000
St. Lazare Station of the Chemin de fer de l'Ouest, Paris	43,062,688
Liverpool-street Station of the Great Eastern Railroad, London	44,377,000
Waterloo Station, London (1898),	28,659,118

Had it been permissible to lay out the station without limitations as to its size and shape, it could have been so planned as to accommodate the traffic more conveniently; but in spite of the enormous amount of traffic and the limited space available for handling it, the business is now being conducted without serious crowding or discomfort. The limit of capacity has not been reached. There has never been any complaint of crowding on the easterly platform, nor on the westerly side of the westerly platform.

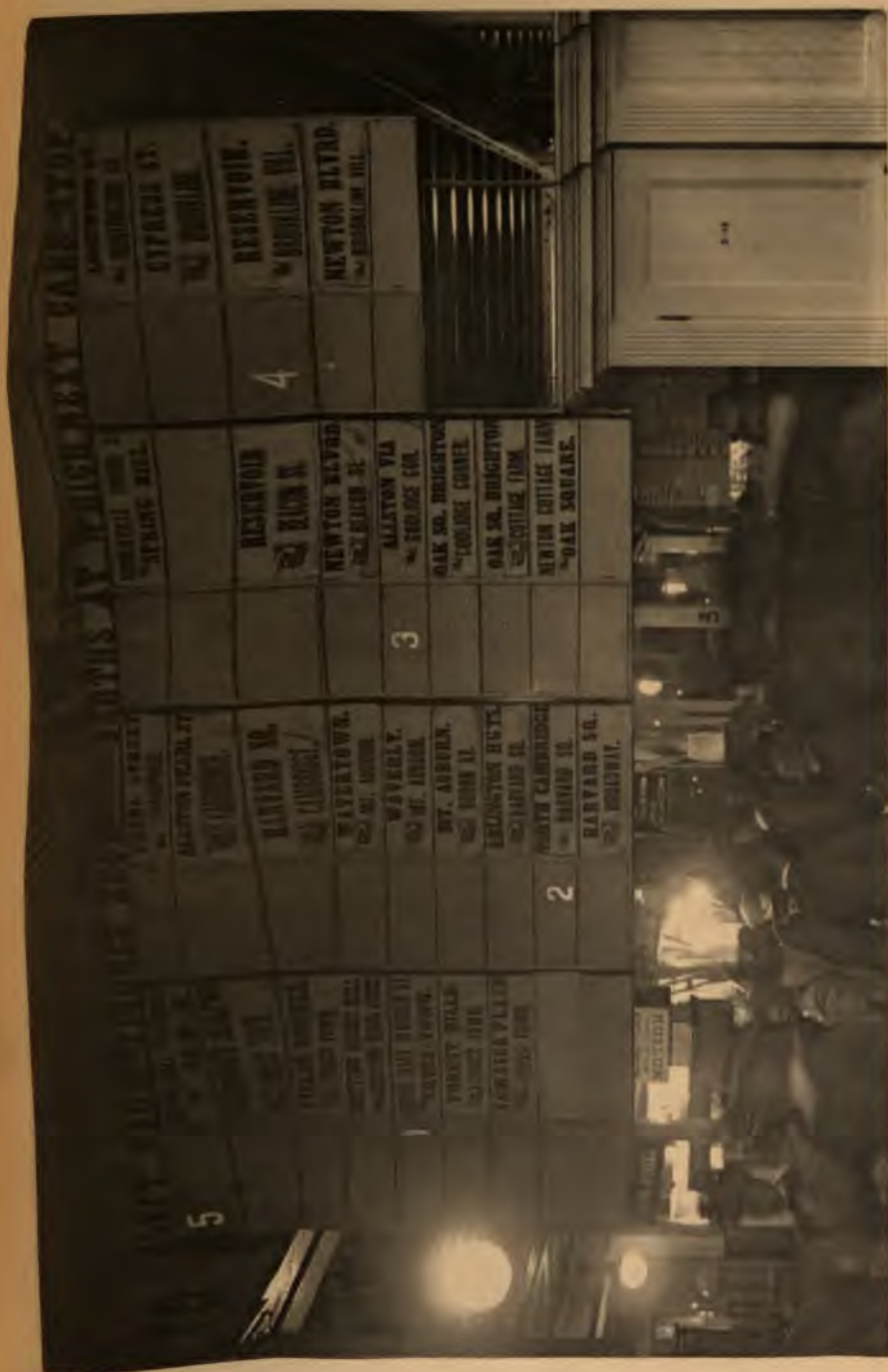
At first there was well-grounded complaint as to crowding, hustling, and confusion on the easterly side of the westerly platform between the hours of 4.30 and 6.00 in the afternoon. This side of the platform at the time of maximum traffic was served by about 180 cars per hour. They ran on more than 20 different routes, and came to the station platform without fixed order. The passengers did not know what cars were coming nor where they were to stop. They crowded to the edge of the platform in order to get the first view of the incoming car, and those whose car had not arrived blocked the way of those attempting to get on board. There were from three to five cars in line at the platform at a time. A passenger at one end of the platform would suddenly discover his car 100 feet distant at the other end. He would hurry along the platform, encountering and jostling with others hurrying for similar reasons in the opposite direction. These elements of excitement and confusion were such as to create danger as well as delay and discomfort. The difficulty was not a surprise to the Commission. When the subway stations were being planned, and before the work of construction was begun, it was anticipated that at the stations doing the largest traffic where several cars bound on different routes would come to the platform at the same time, there would be confusion unless the passengers could be informed in advance where each car was to stop. The problem was apparently without a counterpart in steam or street railway practice. It was obvious that this particular difficulty could not be overcome by any modifications of the size or the shape of the platform, even if such modifications had been possible.

under the limitations prescribed by law. The conclusion then reached was that the only satisfactory remedy lay in the use of indicators showing before the arrival of each car to what line it belonged, and the point in the platform opposite to which it would stop.

Last autumn a card indicator, operated by hand, was first used experimentally. Afterwards electrically illuminated indicators designed by the Commission were, at the request of the Commission, installed by the Elevated Railway Company for the use of passengers taking cars on this crowded side of the platform. These indicators have been operated only during the hours of largest outgoing traffic, namely, from 3 to 6 o'clock in the afternoon. When they are in operation a passenger can wait in the central part of the platform until his car is announced, and he then has at least half a minute to walk to the berth at which his car is to stop. Thus, when a car arrives, the people who want that particular car are at hand, and they are not interfered with by others waiting near the edge of the platform for cars which have not arrived. One indicator is placed at each end of the platform. Both are electrically connected with an elevated observation stand in which is stationed an official who, seeing the cars before they arrive at the platform, determines and announces on the indicators the berths which they will occupy. Upon the indicators are the names of all the routes upon which the cars run arranged in columns and grouped according to the localities which they reach. At one side of the name of each route is a set of five pigeon-holes, each containing an incandescent lamp, which, when lighted, displays a figure from 1 to 5. The operator, who has a switch-board, lights these lamps as needed, and the passenger has merely to watch the line on the indicator on which his route is displayed, and when he sees a number lighted opposite that route he goes to the berth indicated and is ready to take the car upon its arrival.

Tremont-street Traffic.

Counts of traffic on Tremont street, between Bromfield and West streets, taken in December, 1894, before any of the surface cars were removed from the street, and in December, 1898, three months after the surface cars were entirely removed from the street, show that the vehicle traffic exclusive of cars had increased 29.4 per cent., the number of persons in vehicles exclusive of cars had increased 36.2 per cent., the number of people on foot on the sidewalks had increased 10.6 per cent., and the total of persons in vehicles and on foot had increased 12.2 per cent.



NORTHERLY INDICATOR IN THE PARK STREET STATION. THE SOUTHERLY INDICATOR IS FAINTLY SEEN IN THE BACKGROUND. EACH INDICATOR HAS TWO FACES, SO THAT SOME ONE OF THE FACES CAN BE SEEN FROM ANY PART OF THE EASTERLY SIDE OF THE WESTERLY PLATFORM. THE PROMINENT WHITE FIGURES ARE CONSTANTLY CHANGED TO CORRESPOND WITH THE NEAR ARRIVAL OF AND BERTH OCCUPIED BY DIFFERENT CARS.

SPEED STATISTICS.

In 1894, from statistics taken on the 26th, 27th, and 28th of November, it was found that the average time consumed by a car in running on the surface from the junction of Tremont street and Shawmut avenue to the Union station and return was 32 minutes and 52 seconds. The trips taking more than the average time were, as a rule, those made during the hours of greatest traffic. Hence the average time per passenger was greater than the average time per car. Furthermore, those going to take trains could not count on trips being made in the average time. They had to make allowance for numerous special causes of delay. The present average time consumed in passing from the entrance at Pleasant street to the Union station and return is 21 minutes.

The time required in the hours of greatest traffic varies but little from the time required in the hours of least traffic.

On Monday, March 27, and Tuesday, March 28, 1899, statistics were obtained as to the time taken by cars in passing from Dale street, in Roxbury, via Shawmut avenue and the subway, to the Park-street station. On the 27th the record was kept from 1 o'clock P.M. to 6 P.M. and on the 28th from 7 A.M. to 12 M. The average time consumed in making the passage was 20 minutes, the maximum time was 26 minutes, and the minimum 16½ minutes. These figures may prove of value in the future in making comparisons with the operation of the elevated system. For other similar statistics see the Third Annual Report, pp. 6 to 8.

GAS EXPLOSION SUITS.

Many suits were brought as a result of the gas explosion at the corner of Boylston street, on March 4, 1897, for personal injuries and damage. Only one suit has been tried up to the present time, and exceptions therein are now pending before the Supreme Court. It was generally regarded as a test case. This suit was brought by one Wolf Koplan, alleging that he sustained personal injuries. The writ was brought April 1, 1897, and the original defendants named therein were the city of Boston, the Metropolitan Construction Company, the West End Street Railway Company, the Boston Gas Light Company, the Bay State Gas Company, the Edison Electric Illuminating Company, and the Boston Electric Light Company.

Before trial the plaintiff discontinued against the city of Boston, the Bay State Gas Company, and the Boston Electric Light Company. At the close of the plaintiff's testimony

the Court ordered a verdict for the Edison Electric Illuminating Company. The case, therefore, went to the jury against the Metropolitan Construction Company, the West End Street Railway Company, and the Boston Gas Light Company. The jury returned a verdict for the plaintiff for \$3,000 against the Boston Gas Light Company, and verdicts for the Metropolitan Construction Company and the West End Street Railway Company.

The trial was begun Nov. 9, 1898, and the verdict was rendered Dec. 31, 1898.

ALTERATIONS.

The alterations in the subway already made by the Commission at the request of the Boston Elevated Railway Company, under the terms of the Statute of 1897, are the change of location of the southerly stairway at the southbound platform at Park-street station, the construction of the easterly platform at Scollay-square station, a change of grade at the head of Hanover street, and alterations in the shape of platforms at Adams square and Haymarket square.

Other alterations which are in contemplation because of the proposed use of the subway for elevated railroad trains are the elevation of the east side of northbound platforms and the west side of southbound platforms; and the material alteration of the entrance at Pleasant street by which all surface cars will be barred from entering the subway at that point, as described in the last report. These matters have been studied, but plans have not been adopted, inasmuch as the work cannot be done until the company is nearly ready to run its elevated trains.

SUITS AGAINST COMPANIES OWNING UNDERGROUND STRUCTURES.

When the Commission early in its work reached the point where it was necessary to order the removal of underground structures, a controversy arose as to the right of the Commission to compel such removal and relocation at the expense of the corporation owning such structures. Chapter 548 of the Acts of 1894, section 36, reads in part as follows:

Said Commission may order the temporary removal or relocation of any surface tracks in or on any land or way, through or under, or near which any subway, tunnel, or railway, aforesaid, is to be built, also the removal or relocation of any conduits, pipes, wires, or poles of any person or corporation, which it deems to interfere with the construction or operation of any such subway, tunnel, or railway, and the person or corporation owning such tracks, wires, or other property shall comply with said orders.

The first order was given to the Boston Gas Light Company. That company acknowledged the right of the Commission to order such removal and relocation and to compel compliance with its order, but contended that the Commission should bear the expense thereof. To await a decision upon this question by the Courts would so long delay the construction of the subway that the following method of procedure was adopted with a view to a later determination of the rights of the parties. The Commission first ordered the corporation to remove or relocate its pipes or conduits within a stated reasonable time. The corporation made answer that it would comply with the order provided the Commission agreed to pay the actual cost of the work. Thereupon the corporation was notified that if it failed to comply with the order the Commission would have the work done at the expense of the corporation. The result was that the Commission caused the work to be done, employing for that purpose an agent approved by the corporation, and before accepting the work securing a certificate from the corporation that the work was done to its satisfaction.

The amounts paid for work so done are as follows :

Boston Gas Light and Bay State Gas Co's	\$32,917 55
Boston Electric Light Co.	1,200 64
Edison Electric Illuminating Co.	4,392 77
New England Telegraph and Telephone Co.	7,644 74
Total	\$46,155 70

The claims against the various companies have been placed in the hands of the City Solicitor for collection.

CAPACITY OF THE SUBWAY.

During the debate in the Massachusetts House of Representatives over the bill to permit the replacing of street car tracks on Tremont street, that body asked the Commission for certain information in relation to the use of the subway to its full capacity. The reply of the Commission will be found in Appendix B.

AMOUNTS PAID FOR RENTAL OF THE SUBWAY.

The following sums have been paid by the West End Street Railway Company and the Boston Elevated Railway Company as rental for the use of the subway :

Oct. 1, 1897:		
Cost of Sections 1, 2, and 3, including proportion of interest and general expenses	\$1,045,896 29	
1 month's rental on the same from Sept. 1, at 4 7-8 per cent.		\$4,248 95
Jan. 1, 1898:		
Cost of Sections 1, 2, 3, 4, and 5	1,877,605 66	
One quarter's rental		22,883 32
April 1, 1898:		
Cost of Sections 1, 2, 3, 4, and 5	1,913,174 63	
One quarter's rental		23,316 82
July 1, 1898:		
Cost of Sections 1, 2, 3, 4, and 5	2,071,766 52	
One quarter's rental		25,249 65
Oct. 1, 1898:		
Cost of Sections 1, 2, 3, 4, and 5 to Sept. 3 (date of opening of entire subway)	2,081,230 33	
Rental for 2 months and 2 days		17,473 67
Cost of entire subway	4,608,045 59	
Credit for land for widening Canal street	142,023 00	
Net cost	\$4,466,022 59	
Rental for 28 days		16,933 67
Alterations: cost to date	73,111 77	
Rental for 28 days		277 22
Jan. 1, 1899:		
Cost of entire subway	4,551,954 58	
Credit for land appropriated by city for other purposes	473,977 00	
Net cost	\$4,077,977 58	
One quarter's rental		49,700 35
Alterations: total cost	78,692 05	
One quarter's rental		959 06
April 1, 1899:		
Cost of entire subway	4,123,712 61	
¹ Allowance for rentals received, sale of old materials, etc.	23,670 92	
Net cost	\$4,100,041 69	
One quarter's rental	\$49,969 26	
Deduct for over payments made prior to allowance as above	821 24	
Alterations: total cost	\$82,739 04	49,148 02
¹ Allowance for rentals received, sale of old materials, etc.	200 00	
Net cost	\$82,539 04	
<i>Amount carried forward</i>		\$210,190 73

¹ These amounts, while deducted from cost in estimating rental, according to law, are still carried on the books of the Commission and of the City Auditor as part of the cost of the subway.

<i>Amount brought forward</i>	.	.	.	.	\$210,190 73
One quarter's rental	.	.	.	.	\$1,005 95
Deduct for over payments made prior to allowance as above	.	.	.	.	5 87
				<hr/>	1,000 08
July 1, 1899:					
Cost of entire subway	.	.	.	.	\$4,115,627 18
One quarter's rental	.	.	.	.	50,159 21
Alterations: total cost	.	.	.	.	85,875 57
One quarter's rental	.	.	.	.	1,046 61
				<hr/>	
Total rental paid to date:					
For subway	.	.	.	.	\$259,113 66
For alterations	.	.	.	.	3,282 97
				<hr/>	\$262,396 63

The rental due October 1 will be about \$50,200 for the subway and \$2,300 for alterations.

ESTIMATES AND EXPENDITURES.

The following table gives in detail the estimates for the completion of the Subway, as compared with the actual expenditures to date, exclusive of alterations :

SECTION.	CONTRACTS.			OTHER PAYMENTS.		Total to Date.	Est. Total Cost.
	Est. Amount.	Payments.	Extras.	Construction.	Misc.		
1.....	\$176,000 00	\$157,297 87	\$29,545 07	\$15,868 16	\$37,883 66	\$240,594 76	
2.....	254,000 00	263,354 21	14,242 50	37,223 41	49,352 48	364,172 60	
3.....	237,450 00	237,086 94	16,101 20	16,998 54	47,723 95	307,910 63	
3½.....	9,000 00	7,722 27	.....	1,018 08	739 04	9,479 39	\$1,319,629
4.....	318,000 00	343,633 38	25,259 83	30,728 97	76,364 89	475,987 07	
5.....	29,750 00	25,577 00	2,519 21	1,339 83	9,575 25	39,011 29	
6.....	217,500 00	44,131 57	5,000 26	100,759 01	177,156 27	327,047 11	
7.....	144,500 00	138,964 60	478 46	39,759 26	56,460 27	235,662 59	
8.....	74,500 00	76,327 90	2,864 03	9,339 61	11,527 15	100,068 69	373,095
8½.....	60,000 00	64,641 57	1,185 98	3,803 16	7,833 93	77,464 64	157,845
9.....	153,000 00	156,626 17	6,718 36	47,686 04	98,642 56	309,673 13	201,402
10.....	126,750 00	109,858 68	2,352 42	53,128 00	91,347 09	256,686 19	401,023
11.....	80,000 00	90,112 21	7,659 08	8,893 97	18,332 98	124,998 24	402,936
Total	\$1,880,450 00	\$1,705,334 37	\$113,926 40	\$366,546 04	\$682,939 52	\$2,868,746 33	\$3,039,597

Real Estate. Sec. 5 —	\$348,427 25	
“ “ 11 —	134,000 00	
	<hr/>	482,427 25
<i>Miscellaneous.</i>		1,000,000
Expenses of Subway Commission.		
General Expenses	\$14,131 16	
Engineering Expenses	116,464 06	
Interest	401,552 06	607,919
	<hr/>	258,575 60
Total Subway		<hr/>
		\$4,141,896 46
		<hr/>
Pay-Rolls		\$814,455 58
Bills		685,362 88
Special Drafts — Contracts and Construction		1,969,993 22
“ — Real Estate		482,427 25
Interest		258,575 60
Expenses of Subway Commission to July 1, 1894		4,307 42
		<hr/>
		\$4,215,121 95
		78,225 49
Less part of General Expense charged to Bridge and Tunnel and Alterations		<hr/>
Total		\$4,141,896 46
		<hr/>
Bond Issues. — Subway		\$4,500,000 00
Expended		4,141,896 46
		<hr/>
Balance available		\$358,103 54
		<hr/>

Construction.

Engineer's estimate by sections immediately
prior to letting contracts, \$3,039,597 00
Actual cost 2,868,746 33

Actual less than estimated expenditure
by \$170,850 67

Administration, Engineering, etc.

20% of final estimate . . . \$607,919 00
Actual expenditure 532,147 28

Actual less than estimated expenditure
by 75,771 72
This item estimated at 20% ; actual, 17½%.

Estimated cost of subway, including real
estate, and without inter-
est \$4,647,516 00
Actual cost without interest, 3,883,320 86

Actual less than estimated expenditure
by 764,195 14

*Original Estimate on which Commission voted to construct
Subway.*

Construction \$3,300,000 00
Administration, engineer-
ing, contingencies, and
interest 700,000 00
Real estate 1,000,000 00
\$5,000,000 00
Actual cost of subway, including interest . 4,141,896 46
\$858,103 54

EAST BOSTON TUNNEL.

In accordance with the vote of July 19, 1898, as given in the last report, the Commission made preparation for the construction of the tunnel to East Boston. On August 23 a public hearing was given at which the chief discussion was as to the route to be selected. At this meeting a preference was expressed for the South Ferry route.

Application having been made to the Secretary of War for permission for the construction of a tunnel under Boston Harbor, that permission was received September 20.

When action was begun under Chapter 500 of the Acts of 1897 the Commission interpreted section 17 as requiring an underground or physical connection with the subway. It reported to that effect to the Legislature in a communication of date of Jan. 27, 1898. At the hearing which was given upon that communication the Corporation Counsel expressed the opinion that this interpretation was incorrect and that the statute permitted of the construction of a tunnel either with or without an underground or physical connection with the subway. The Committee, accepting this interpretation, reported that no legislation was necessary, and this report was adopted by the Legislature. The communication to the Legislature and the opinion of the Corporation Counsel are printed in the fourth annual report, pp. 24 and 25.

On October 18 the following vote was passed :

WHEREAS, The Corporation Counsel has expressed the opinion that under section 17 of Chapter 500 of the Acts of the year 1897 this Commission is authorized to build a tunnel or tunnels to East Boston, either from the surface at a point on or near Hanover street or from any subway or subways constructed under the authority of chapter 548 of the Acts of the year 1894,

Voted, That the construction of a tunnel or tunnels beginning on or near Hanover street in the city of Boston or beginning at such other point or points as may be proper for a suitable connection with the subway or subways authorized by chapter 548 of the Acts of the year 1894, thence running to a point at or near Maverick square in that part of Boston called East Boston, making there a suitable connection with the surface tracks, be proceeded with, and that as a preliminary the Chief Engineer be instructed to have surveys, estimates, and plans made for such tunnel or tunnels.

On November 23 specifications were approved for the construction of Section A, which was located in East Boston, beginning in Maverick square and running under Lewis street, to a point about fifty feet northeast of Marginal street. On the following day bids were advertised for. On November 29 the route of the tunnel from East Boston to Atlantic avenue in Boston was adopted, beginning in Maverick square, proceeding under Lewis street, and reaching the shore on the Boston side at the South Ferry, thence continuing under Eastern avenue to Atlantic avenue. On December 1 notice was received of the filing of an application to the Supreme Court for an injunction to restrain the Commission from requesting the issue of, and the City Treasurer from issuing, bonds of the city for the construction of a tunnel to East Boston as proposed. Subsequently the Boston Elevated Railway Company and the West End Street Railway Company were joined as defendants. By advice of counsel, immediately upon receipt of this notice the advertisement for bids was withdrawn and possible bidders notified that all construction

matters relating to the tunnel would be suspended pending the determination of the proceedings in court. The case was heard in February before a single justice and by him reported to the full bench.

On February 16, prior to the hearing, the following vote was passed :

WHEREAS, The statutes creating this Commission and providing for the construction of the subway, and a tunnel to East Boston, contemplate a system of public travel to be conducted by street railway cars,

Voted, That in the judgment of this Commission a connection by surface street railway tracks between the proposed tunnel to East Boston and the subway is a suitable connection within the meaning of section 17 of Chapter 500 of the Acts of 1897.

Also, on February 23, it was

Voted, That the construction of the tunnel west of the point indicated in the vote of Tuesday, Nov. 29, 1898, shall be such that the tracks shall rise to the surface of the ground by an inclined way.

On July 3 the Supreme Court rendered a decision that the connection voted by the Commission between the subway and the tunnel was not a "suitable connection" within the requirements of the statutes, and the prayer of the petitioners for an injunction was granted upon that ground, the Court not passing upon the question as to the constitutionality of the tunnel act. The full text of the Court's decision will be found in Appendix A.

On July 18, 1899, the following vote was passed :

WHEREAS, In the opinion of the Supreme Court rendered in the case of *Browne et al.* against *Turner et al.* this Commission is not authorized to construct a tunnel to East Boston in the manner described in the following votes; now therefore it is

Voted, That the following vote passed on Oct. 18, 1898, and the following vote passed on Feb. 16, 1899, and the following vote passed on Feb. 23, 1899 (see votes above), be and are hereby rescinded.

On August 3 it was

Voted, That the Commission proceed with the construction of a tunnel from East Boston as required by Chapter 500, Statutes 1897, and as interpreted by the Supreme Judicial Court in *Browne et al. v. Turner et al.*

On February 9 the following was received :

CITY OF BOSTON.

IN BOARD OF ALDERMEN, Feb. 6, 1899.

Ordered, That the Boston Transit Commission be requested to inform this Board, at its next meeting, why work has not been commenced on the tunnel to East Boston, as provided in section 26 of Chapter 548 of the Acts of 1894, and acts in amendment thereof and addition thereto.

Passed.

(Signed) J. M. GALVIN,
City Clerk.

A true copy.

Attest:

(Signed) J. M. GALVIN,
City Clerk.

The reply thereto is appended :

BOSTON TRANSIT COMMISSION, 20 BEACON STREET,
BOSTON, Feb. 9, 1899.

To the Honorable Board of Aldermen :

The Boston Transit Commission has received the request of your Board for information as to the reasons why work has not been commenced on the tunnel to East Boston as provided in section 26 of Chapter 548 of the Acts of 1894, and the acts in amendment thereof and in addition thereto.

Chapter 548 of the Acts of the year 1894 gave to this Commission discretionary power to construct a tunnel or tunnels from a point on or near Scollay square in the city of Boston, where a suitable connection may be made with the subway or subways provided for by that act, to a point on or near Maverick square in that part of Boston called East Boston, where a suitable connection with surface tracks may be made.

The appropriation provided in that act was insufficient to build such a tunnel in addition to the building of the subway.

By chapter 500 of the Acts of the year 1897, the Commission was required to construct a tunnel to East Boston so soon as the Elevated Railway should be authorized to begin the construction of its railroad over the route first applied for, as provided in section 13 of said act. For such construction an additional appropriation of \$500,000 was made. This appropriation, together with the balance of the original appropriation available for the construction of the tunnel, was insufficient to construct a tunnel to East Boston from a point on or near Scollay square, under the Act of 1894, but the estimates indicated that it was sufficient to construct a tunnel to East Boston beginning at a point on the surface on or near Hanover street, and the Corporation Counsel was of the opinion that the building of such a tunnel was within the scope and intent of the Act of 1897.

On the 19th of July, 1898, the Elevated Railway Company having been authorized to begin the construction of its railroad as provided in the act, it was

“ Voted, That the construction of the East Boston tunnel be proceeded with in accordance with the statute requirements.”

The Chief Engineer of the Commission was forthwith instructed to proceed with the preparation of plans and specifications, and on November 23 an advertisement for bids for the construction of Section A of the tunnel, being the East Boston entrance thereto, was published.

Before the date fixed for the reception of bids the members of the Commission were served with a notice of the pendency of proceedings before the Supreme Judicial Court contesting the constitutionality of the Act of 1897 and the right of the Commission to proceed thereunder in the construction of a tunnel and to expend the funds of the city therefor. Thereupon under the advice of counsel, all work in relation to the tunnel was suspended pending the hearing and determination by the Supreme Judicial Court upon the questions presented.

Respectfully submitted,

BOSTON TRANSIT COMMISSION,

By GEORGE G. CROCKER, *Chairman,*

B. LEIGHTON BEAL, *Secretary.*

On July 18 the following was received from the City Council :

CITY OF BOSTON,
IN BOARD OF ALDERMEN, July 3, 1899.

Ordered, That the Board of Transit Commissioners be requested to prepare plans for the construction of a tunnel to East Boston in accordance with the decision of the Supreme Court recently rendered, and that they be further requested to commence the construction of said tunnel at the earliest date possible, in order that the citizens of East Boston may be properly and quickly provided with rapid transit.

Passed. Sent down for concurrence. July 13 came up concurred.
A true copy.

Attest:

(Signed)

J. M. GALVIN;

City Clerk.

Details of the engineering work done during the year in connection with the tunnel will be found in the report of the Chief Engineer.

CHARLESTOWN BRIDGE.

As will be seen by the report of the Chief Engineer for Charlestown Bridge, that structure is substantially completed, and only awaits the delivery of certain machinery for the adjustment of the draw. It is expected that the bridge will be opened for public travel in two or three months.

The opening of the new bridge will be followed, in accordance with the terms of the license issued by the War Department, by the removal of the old Charles-river Bridge, the contract for which has already been awarded.

The dimensions of the bridge are here given as a matter of record:

Length of Charlestown approach . . .	610 feet.
“ “ Boston approach . . .	220 “
“ “ Charlestown abutment to draw . . .	425 “
“ “ Boston abutment to draw . . .	425 “
“ “ draw . . .	240 “
Total length of bridge . . .	1,920 “
Width of sidewalks, each . . .	10 “
“ “ roadways “ . . .	29 “
“ “ car reservation . . .	22 “
Total width of bridge . . .	100 “
Number of spans over water . . .	Ten.
“ “ stone piers . . .	Ten.
Width of draw-openings, each . . .	50 feet.
Height of draw above mean high water . . .	23 “
Weight of draw . . .	1,200 tons.
Approximate weight of steel used . . .	4,500 “

An historical sketch will be found in Appendix C.

PAYMENTS TO SINKING FUND.

The following premiums on bond issues and receipts from all sources have been paid into the Rapid Transit Sinking Fund during the year, not including income from investments or interests on deposits:

On Charlestown Bridge Account.

1898.	
Oct. 13. Rentals of Charlestown Bridge property	\$155 37
1899.	
July 1. Premium on \$200,000 $3\frac{1}{2}$ per cent. bonds	14,554 00
	<hr/>
	\$14,709 37
	<hr/>

Condition of the Sinking Fund to date, including interest on investments:

SUBWAY (INCLUDING ALTERATIONS).

(Debt, \$4,700,000.)	
Amount of fund, Aug. 15, 1898	\$278,465 96
Interest on bank deposits, Aug. 15, 1898, to date	156 71
Interest on investments, Aug. 15, 1898, to date	10,407 50
Revenue received, Aug. 15, 1898, to date	3,299 81
	<hr/>
	\$292,329 98
	<hr/>

CHARLESTOWN BRIDGE, No. 1.

(Debt, \$750,000, inside debt limit.)	
Amount of fund, Aug. 15, 1898	\$26,904 59
Interest on bank deposits, Aug. 15, 1898, to date	225 16
Interest on investments, Aug. 15, 1898, to date	987 00
Revenue received, Aug. 15, 1898, to date	2,242 46
Requirement for debt	9,301 00
	<hr/>
	\$39,660 21
	<hr/>

CHARLESTOWN BRIDGE, No. 2.

(Debt \$400,000, outside debt limit.)

Amount of fund, Aug. 15, 1898	\$11,896 65
Interest on bank deposits, Aug. 15, 1898, to date	95 43
Interest on investments, Aug. 15, 1898, to date	385 00
Debt requirement	2,646 00
Premium on loan	14,554 00
	<u>\$29,577 08</u>

STATEMENT OF EXPENSES.

The following is a classified statement of the expenses of the Commission for the year ending Aug. 15, 1898 :

SUBWAY.

General Expenses:

Office — Repairs	\$16 69
Furniture	18 75
Supplies	661 27
Stationery and printing	2,262 90
Fuel and light	195 37
Rental	1,500 00
Stenographers	2,657 71
Messenger	936 00
Clerks	832 00
Janitor	269 10
Salaries of Commissioners and Secretary	25,915 00
Total	<u>\$35,264 79</u>
Transferred to other accounts:	
Charlestown Bridge	\$11,381 65
Alterations	10,211 52
East Boston Tunnel	14,521 70
	<u>36,114 87</u>

Total of General Expenses reduced by \$850 08

ENGINEERING DEPARTMENT.

Rooms — Repairs	\$5 90
Furniture	15 25
Supplies	636 22
Stationery and printing	1,995 09
Fuel and light	236 92
Rental	1,510 00
Janitor	269 10
Messengers	354 74
Stenographers	1,846 21
Instruments	8 10
Supplies	360 11
Amount carried forward	<u>\$7,237 64</u>

<i>Amount brought forward</i>	\$7,237 64	
H. A. Carson, Chief Engineer	3,999 50	
Skilled service	4,610 42	
	<hr/>	
Total		\$15,847 56

MISCELLANEOUS.

Legal and expert advice	\$6,530 00	
Labor	1,831 39	
	<hr/>	
		8,361 39
		<hr/>
Less transferred to account of Alterations and Tunnel .		\$24,208 95
		3,660 00
		<hr/>
Balance on account of Subway		\$20,548 95

SECTION ONE.

(Public Garden to old Public Library, 2-track; Tremont street from north of Mason to West street, 4-track.)

Construction	\$23 79	
Labor	304 28	
Office supplies	10	
Field supplies	56 89	
Teaming	46 48	
	<hr/>	
Total		431 54

SECTION TWO.

(Old Public Library north of Mason street, 2 and 4 track, and station.)

Construction	\$41 61	
Labor	164 12	
Legal and expert advice	262 40	
Field supplies	2,414 48	
	<hr/>	
Total		2,882 61

SECTION THREE.

(West street to Park street, 4-track, and station.)

Construction	\$16 19	
Granolithic work	331 87	
Labor	116 12	
Office supplies	50	
Field supplies	1,235 32	
Stationery and printing	30 00	
Teaming	8 96	
	<hr/>	
Total		1,738 96

SECTION THREE AND ONE-HALF.

(About 25 feet each of two single-track subways from Section 3 to Section 6.)

Labor	\$7 40	
	<hr/>	
Total		7 40
		<hr/>
<i>Amount carried forward</i>		\$25,609 46

Amount brought forward \$25,609 46

SECTION FOUR.

(Tremont street, Section 2, to Hollis street, 2-track; Hollis to Warrenton street, 4-track.)

Metropolitan Construction Company	\$11,250 00	
Construction	36 63	
Labor	635 45	
Legal and expert advice	33 16	
Office supplies	3 01	
Field supplies	16,921 71	
Teaming	85 26	
Water-pipes	145 54	
Eliot-street sewer, field supplies	120 00	
	<hr/>	
Total		29,230 76

SECTION FIVE.

(Warrenton street to Pleasant street, 4-track, and incline.)

Legal and expert advice	\$2,200 00	
	<hr/>	
Total		2,200 00

SECTION SIX.

(Tremont street, Section 3½, to near Scollay square, 2-track.)

Construction	\$22 50	
Field supplies	1,137 20	
Labor	296 16	
Teaming	58 36	
	<hr/>	
	\$1,514 22	
Credit, material sold	10 00	
	<hr/>	
Total		1,504 22

SECTION SEVEN.

(Scollay-square station.)

Woodbury & Leighton, stations	\$11,244 91	
Charles Brigham, architect	500 00	
Construction	4,946 40	
Electric conduits	1,256 01	
Field supplies	211 46	
Labor	295 11	
Teaming	21 90	
Water-pipes	262 33	
	<hr/>	
Total		18,738 12

SECTION EIGHT.

(Hanover street, Section 7 to Section 9, 2-track.)

Labor	\$85 80	
Total		85 80
	<hr/>	
<i>Amount carried forward</i>		\$77,368 36

Amount brought forward \$77,368 36

SECTION EIGHT AND ONE-HALF.

(Cornhill, Section 7 to Section 9, 2-track.)

Construction	\$4 99	
Electric conduits	26 18	
Field supplies	2,879 17	
Labor	158 50	
Teaming	8 76	
	<hr/>	
Total		3,077 60

SECTION NINE.

(Adams square, Washington street to Hanover street, 3-track, and station.)

Richardson & Young	\$9,000 00	
Woodbury & Leighton, stations	11,244 91	
Charles Brigham, architect	500 00	
Construction	4,172 50	
Office supplies	10	
Field supplies	258 67	
Labor	239 08	
Teaming	18 33	
	<hr/>	
	\$25,433 59	
Credit, deduction from account of A. & P. Roberts Co.	53 82	
	<hr/>	
Total		25,379 77

SECTION TEN.

(Washington street, Hanover street to Haymarket square, 4-track, and station at Haymarket square.)

Construction	\$1,041 52	
Field supplies	2,773 91	
Labor	569 76	
Teaming	53 00	
Water-pipes	5 42	
	<hr/>	
Total		4,443 61

SECTION ELEVEN.

(Haymarket square to Travers street, 4-track, and incline.)

Charles Linehan	\$7,829 63	
Construction	3,885 92	
Office supplies	2 19	
Field supplies	2,659 79	
Labor	1,016 66	
Legal and expert advice	600 00	
Teaming	150 84	
	<hr/>	
Total		16,145 03

INTEREST.

Paid by City Treasurer	\$41,450 31	
	<hr/>	
Total		41,450 31
	<hr/>	
<i>Amount carried forward</i>		\$167,864 68

Amount brought forward \$167,864 68

ALTERATIONS.

General Expenses	\$13,245 02	
Interest	1,905 56	
	<hr/>	15,150 58

SECTION FIVE.

Skilled service	\$58 94	
	<hr/>	
Total		58 94

SECTION SEVEN.

(Easterly platform.)

Land damages	\$103,607 40	
John S. Jacobs & Son	353 92	
George W. Judd	1,165 36	
Norcross Bros.	3,939 91	
Construction	239 21	
Electric conduits	1,656 78	
Field supplies	74 42	
Labor	299 90	
Skilled service	23 86	
Teaming	2 35	
	<hr/>	
Total		111,363 11

EAST BOSTON TUNNEL.

Proportion of General Expenses	\$19,148 70	
E. A. Clark, borings	6,439 70	
B. F. Smith & Bro., borings	1,618 77	
Stenographer	498 44	
Skilled service	6,453 06	
Messenger	61 26	
Teaming	15 30	
Office supplies	245 50	
Field supplies	416 99	
Advertising	37 79	
Labor	567 07	
Legal and expert advice	5,441 43	
Stationery and printing	25 00	
	<hr/>	
Total		40,969 01

SECTION A.

Construction	\$491 48	
Advertising	43 98	
Office supplies	51	
Stationery and printing	319 17	
	<hr/>	
Total		855 14

CHARLESTOWN BRIDGE.

Proportion of General Expenses	\$11,381 65	
Perkins & White (Draw Foundation)	20,641 26	
D. F. O'Connell (Charlestown Approach)	17,345 12	
" " " (Water-street Pier)	2,600 00	
A. & P. Roberts Co. (Water-street Span)	4,639 98	
	<hr/>	
<i>Amounts carried forward</i>	\$56,608 01	\$336,261 46

<i>Amounts brought forward</i>	\$56,608 01	\$336,261 46
Norcross Bros. (Water-street Span)	8,626 55	
Pennsylvania Steel Co. (Draw)	79,764 00	
Woodbury & Leighton (Superstructure)	58,417 88	
" " (Boston Approach)	16,032 75	
D. J. Kiley & Co.	17,509 17	
Jones & Meehan	20,253 39	
Grade damages	6,000 00	
Land damages	29,344 22	
Halsted & McNaugher	1,170 16	
Construction	75,988 47	
Stationery and printing	458 81	
Instruments	8 14	
Office supplies	281 93	
Field supplies	10,632 26	
Advertising	159 71	
Labor	18,627 28	
Legal and expert advice	1,305 72	
Teaming	2,757 47	
Sidewalks	3,927 00	
William Jackson, Chief Engineer	2,000 00	
Skilled service	12,346 58	
Total		422,219 50
Total		\$758,480 96
Less Decrease in General Expenses		850 08
Grand Total		\$757,630 88

SUMMARY.

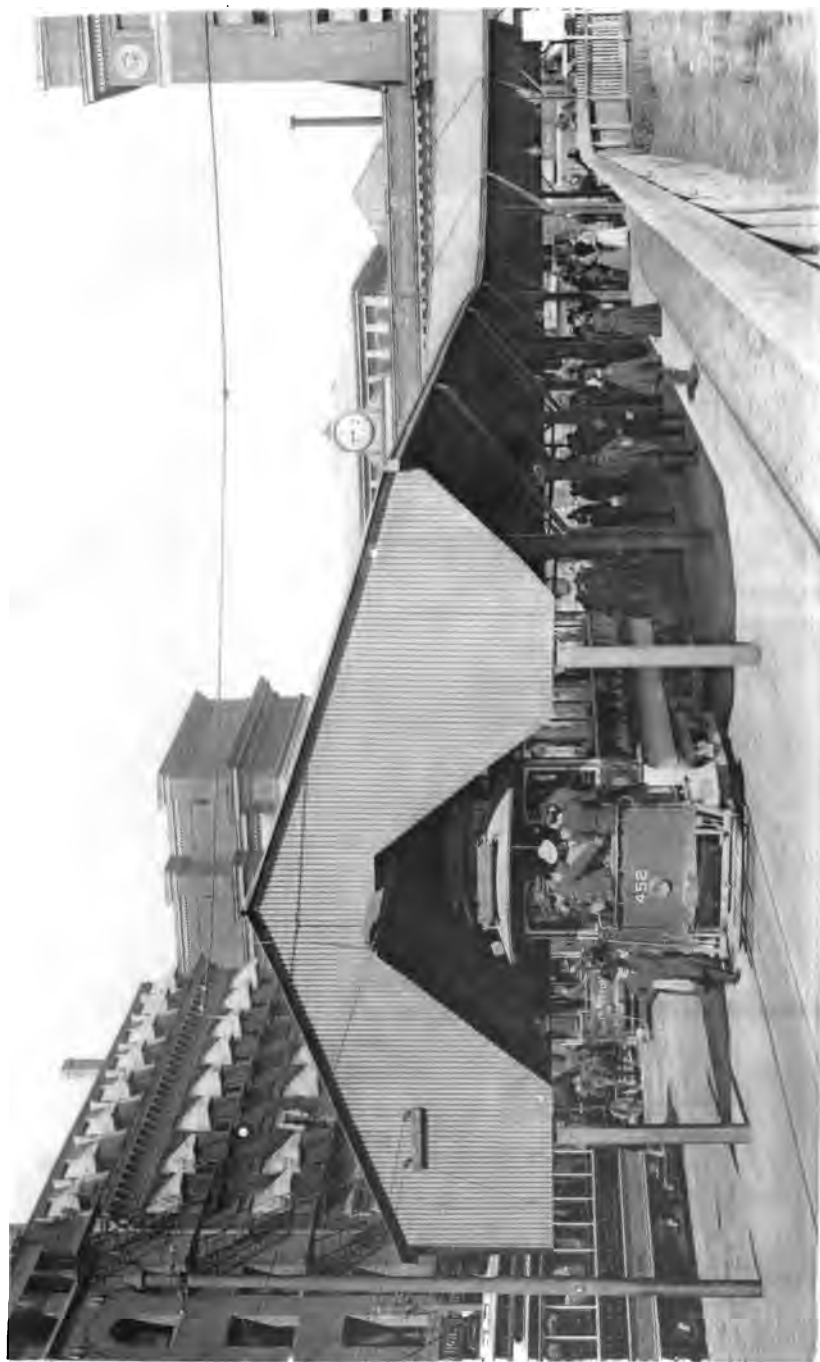
	From beginning of work to Aug. 15, 1898.	Aug. 15, 1898, to Aug. 15, 1899.	Total.
Subway.—Subway Com- mission	\$14,131 16		\$14,131 16
Part of General Ex- penses	117,314 14	¹ \$850 08	116,464 06
Engineering and Miscel- laneous	381,003 11	20,548 95	401,552 06
Section One	240,163 22	431 54	240,594 76
Two	361,289 99	2,882 61	364,172 60
Three	306,171 67	1,738 96	307,910 63
Three and one- half	9,471 99	7 40	9,479 39
Four	446,756 31	29,230 76	475,987 07
Five	385,238 54	2,200 00	387,438 54
Six	325,542 89	1,504 22	327,047 11
Seven	216,924 47	18,738 12	235,662 59
Eight	99,972 89	85 80	100,058 69
Eight and one- half	74,387 04	3,077 60	77,464 64
Nine	284,293 36	25,379 77	309,673 13
Ten	252,242 58	4,443 61	256,686 19
Eleven	² 242,853 21	16,145 03	258,998 24
Interest	217,125 29	41,450 31	258,575 60
Total	\$3,974,881 86	\$167,014 60	\$4,141,896 46

¹ Decrease.² \$858,853.21, less \$616,000 received for sale of surplus land.

	From beginning of work to Aug. 15, 1898.	Aug. 15, 1898, to Aug. 15, 1899.	Total.
Alterations. — General . . .	\$121 59	\$13,245 02	\$13,366 61
Section Three . . .	2,391 07		2,391 07
Five . . .	28 54	58 94	87 48
Seven . . .	61,246 03	111,363 11	172,609 14
Nine . . .	3 00		3 00
Ten . . .	439 38		439 38
Interest . . .		1,905 56	1,905 56
	<u>\$64,229 61</u>	<u>\$126,572 63</u>	<u>\$190,802 24</u>
Subway Total . . .	<u>\$4,039,111 47</u>	<u>\$293,587 23</u>	<u>\$4,332,698 70</u>
East Boston Tunnel. — Mis- cellaneous . . .	\$8,824 48	\$40,969 01	\$49,793 49
Section A . . .		855 14	855 14
	<u>\$8,824 48</u>	<u>\$41,824 15</u>	<u>\$50,648 63</u>
Bridge. — Part of General Expenses . . .	\$29,328 53	\$11,381 65	\$40,710 18
Engineering . . .	643,730 43	410,837 85	1,054,568 28
	<u>\$673,058 96</u>	<u>\$422,219 50</u>	<u>\$1,095,278 46</u>
Grand Total . . .	<u>\$4,720,994 91</u>	<u>\$757,630 88</u>	<u>\$5,478,625 79</u>

The reports of the Chief Engineer and of the Chief Engineer for Charlestown Bridge are appended.

GEORGE G. CROCKER,	} <i>Boston Transit Commission.</i>
CHARLES H. DALTON,	
THOMAS J. GARGAN,	
GEORGE F. SWAIN,	
HORACE G. ALLEN,	



TEMPORARY SHELTER ON CANAL AND CAUSEWAY STREETS TO BE USED BY PASSENGERS ON SUBWAY CARS UNTIL THE RE-ARRANGEMENT OF TRACKS TO CONNECT WITH ELEVATED STRUCTURE. (LOOKING NORTHWEST.)

THE HELIOTYPE PRINTING CO., BOSTON.

REPORT OF THE CHIEF ENGINEER.

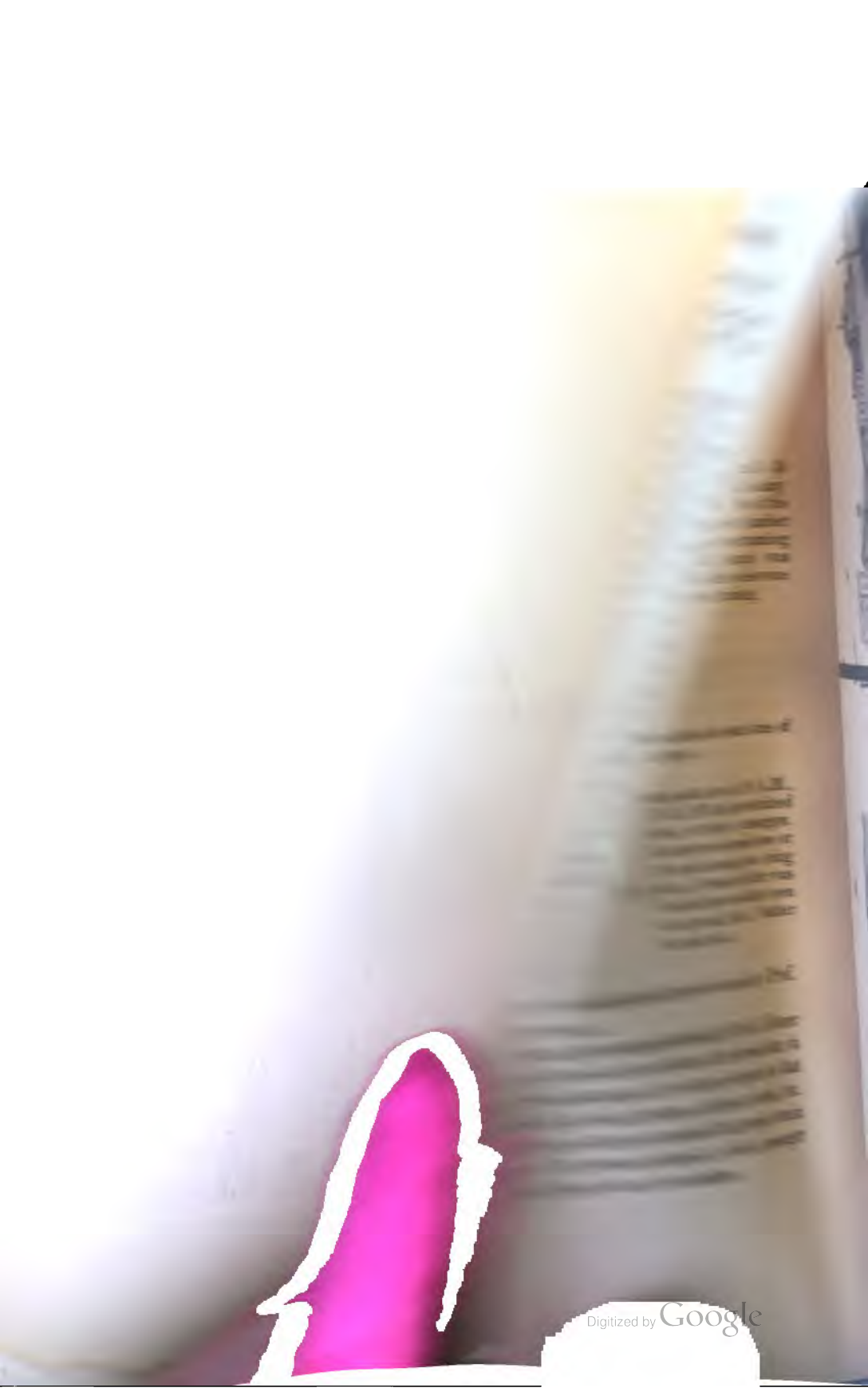
BOSTON, Aug. 15, 1899.

GEORGE G. CROCKER, CHARLES H. DALTON, THOMAS J. GARGAN, GEORGE F. SWAIN, HORACE G. ALLEN,
Boston Transit Commissioners:

GENTLEMEN: The portion of the subway south of Park street was completed prior to Sept. 1, 1897, and was in use on that date. The remaining portion was substantially completed early in July, 1898, and was in use by the cars of the Boston Elevated Railway Company on the third of the following September. The engineering department has since that time been principally engaged in studies connected with the proposed East Boston tunnel. It has, however, in addition, designed and superintended the construction of a passenger shelter of iron and steel near Causeway street; has made some studies with relation to the use of the present subway stations; and some three hundred record and construction plans. It has caused to be constructed a grated opening in the sidewalk over the ventilating chamber at the north-east corner of Hanover and Washington streets. It has worked out some details in connection with an indicator (illustrated by Plate 1) to notify station passengers of the position to be taken by approaching cars. It has superintended making repairs in the roof of the subway where injury has been done by various companies working on emergency permits from the Street Department, so far as such injuries have been discovered; and has done various other minor matters in connection with the existing subway.

SHELTER ON CANAL AND CAUSEWAY STREETS FOR
PASSENGERS USING THE SUBWAY CARS.

This shelter, illustrated by Plates 2 and 3, is intended to last only until the tracks are rearranged for cars to run on the elevated structure. It is made of steel covered with corrugated iron and extends for 171 linear feet on Canal street and 51 linear feet on Causeway street, covering an area of about 6,400 square feet. The contractor for the work was the New England Structural Company. The contract prices for it were as follows: The sum of \$1,367 for the straight southerly portion on Canal street and \$171 per ton for the 11½ tons in the curved northerly portion on Causeway street; making





TEMPORARY SHELTER ON CANAL AND CAUSEWAY STREETS TO BE USED BY PASSENGERS OF LOOKING GLASS AND THE SUBWAY UNTIL THE RE-ARRANGEMENT OF TRACKS TO CONNECT WITH ELEVATED STRUCTURE. (SOUTHEAST)

a total price of about \$3,333 and an average price of about 60 cents per square foot of the whole space covered.

RELATIVE PURITY OF AIR IN THE SUBWAY.

Investigation has been made as to the relative purity of the air inside the subway. The following table shows the results of tests for the presence of carbon dioxide (carbonic acid gas) :

	Parts in 10,000 volumes.	REMARKS.
Boylston-street station, 5 feet above southbound platform	9.45	Samples taken between 5 and 5:30 P.M., on week days in January and February, 1899. One of the fans in the West-street chamber is believed to have been running when the third sample was taken. In the other cases none of the fans were running.
Midway between the Boylston-street station and the Winthrop school ventilating chamber	6.53	
Park-street station, 5 feet above the southbound platform	7.78	
Adams-square station, 5 feet above platform	6.62	
Haymarket-square station, 5 feet above northbound platform	9.13	
On the street in the central part of the city	4.5 to 5.9	Made at about the same time of the year.
In the centre of a car on Boylston street about to enter the subway	24.97	Sample taken about 8:30 A.M., Feb. 25, 1899, and car contained about sixty-five passengers. Rear door was opened once or twice while sample was being taken. Forward ventilator was closed and rear ventilator open about one-half inch. Weather clear and cold.

All of the above-mentioned analyses were made by Prof. Henry Carmichael.

The following, from examples furnished by Prof. S. Homer Woodbridge, shows that the air taken at the busiest hour in the most crowded station in the subway is superior to that usually provided in halls, theatres, churches, schools, etc. In this connection it may be remarked that people remain several hours in the rooms referred to, while a passenger remains in the subway but a few minutes.



TEMPORARY SHELTER ON CANAL AND CAUSEWAY STREETS TO BE USED BY PASSENGERS ON SUBWAY CARS UNTIL THE RE-ARRANGEMENT OF TRACKS TO CONNECT WITH ELEVATED STRUCTURE. (LOOKING SOUTHEAST.)

THE HELIOTYPE PRINTING CO., BOSTON.

		Parts of carbon dioxide. in 10,000 volumes.
City Hall Council Chamber, two-thirds full.....	{	Floor, 10.12 to 14.60
Large public hall in Boston, near open door, with in-draught	{	Gallery, 13.22 to 18.58
Another hall in Boston, well filled.....	{	13.93
	{	32.59 to 36.43
	{	(the latter being in the gallery).
Four of the principal theatres in Boston		16.16 to 48.7
Two large churches, Boston and Brookline.....		12.45 to 18.19
Twelve schools in Boston, Cambridge, Chelsea, etc.,		7.1 to 23.50

The conditions as to fans in the subway are as follows :

LOCATION OF VENTILATING CHAMBERS.	Number of fans provided for.	Diameters of fans, feet.	Conditions, Aug. 15, 1899.
In front of Winthrop school-yard, Tremont street, section 4.....	2	7	The fans are in- stalled.
Boylston-street mall of the Com- mon	1	7	Only a small temporary fan is installed.
Tremont-street mall of the Com- mon, nearly opposite West street,	2	8	The fans are in- stalled.
King's Chapel yard	2	7	The fans are not installed.
Cornhill, near Franklin avenue ...	1	7	The fans are not installed.
Hanover street, near Marston's restaurant	1	7	The fans are not installed.
North-easterly corner of Hanover and Washington streets	2	8	The fans are not installed.

The Second Vice-President of the Boston Elevated Railway Company states that it is the practice to operate these fans from 7 o'clock A.M. until 7 o'clock P.M., except when idle for repairs or otherwise, and excepting during moist weather, when trouble from condensation requires that the fans be shut down.

The air in the subway will probably be still further improved when the remaining fans are installed and put in operation.

LONDON AND PARIS UNDERGROUND ELECTRIC RAILROADS.

In some of the preceding reports reference has occasionally been made to some of the existing or proposed underground railroads in European cities. The writer and a member of the Commission visited Paris and London last spring, and at the request of the Commission some additional remarks in regard to the underground electric roads of those cities are appended.

London Underground Electric Railroads. — The original City and South London underground electric road, which has been referred to more than once in preceding reports, is about $3\frac{1}{2}$ miles long, extends from King William street to Stockwell road, is built of two cast-iron tubes each from 10 feet 3 inches to 10 feet 6 inches interior diameter, and has been in operation since Dec. 18, 1890. The road is in process of extension in a northerly direction under Moorgate street and City road to Angel P. H. In order to make this extension, a new line was carried under the Thames, joining the old line about a third of a mile south of the river. This railway has also been extended on the south to Clapham common. The total length of the original road and these extensions will be, after completion, about 6 miles.

A structure similar to the city and South London road, but of larger diameter, between Waterloo station and the Mansion house, whose construction was alluded to in former reports, has been completed and in service for some months.

Another underground road is in course of construction which will serve to join the Waterloo station with the Great Central terminus. Proposed extensions will reach Euston, Paddington, and other stations.

The Central London road, under Oxford street and various other connecting streets between the Bank of England and Shepherds' Bush, a distance of over 6 miles, will probably be completed this year. This road, in common with all the other underground electric roads in London, was constructed mostly by tunnelling in the very favorable bed of clay which underlies this city. The depth of the tunnel below the surface is in some places as much as 70 feet. It consists of two cast-iron tubes, each with an interior diameter of $11\frac{1}{2}$ feet. Its stations have an interior diameter of about 21 feet. The entrances to the stations are nearly all on property purchased for the purpose, and are about half a mile apart. The cost of the Central London road *per mile* has been substantially as follows :

Works with stations half a mile apart, and platforms 325 feet long	\$1,144,000
Land	487,000
Electric locomotives and carriages for a 2½-minute service, repair-shops, interest during construction, professional charges, and working capital, etc.	1,167,000
	<hr/>
	\$2,798,000

The stations that are placed at considerable depths from the surface of the ground in all of the before-mentioned electric railways are provided with ample elevator service.

These roads go directly across the most important part of London in various directions, instead of going around it like the old Metropolitan and District Railroad.

The last-mentioned railroad continues to be used by steam locomotives. There is, however, a project for an additional express line underneath a part of it, from the city to South Kensington, or some station at the West End, to be operated by electricity.

In all about 5 miles of underground electric roads are now in service in London, 15 more are in course of construction, 9 more are authorized, and various others are projected. In the near future London will probably have about 40 miles of electric underground railways in service.

The electric subway lines already built in London have been successful financially, have provided quick transit for passengers, and have tended to relieve the congestion in the overhead streets. Their success has tended to hasten construction in that city, as indicated above, and in Paris.

Paris Underground Electric Railroads. — On the line of the railroad known as the Ceinture, which runs around Paris near the outskirts, there are a number of short tunnels of ordinary construction, and nearer the centre of the city there is another (referred to in the Second Annual Report), extending under the Boulevard St. Michel and other public ways from near the Luxembourg to the old station of the Sceaux Railroad not far from the Observatory. This underground road employs steam locomotives.

At present there are no underground electric railways in operation in Paris, but in the near future there will be a very extensive system. The first construction of this character has been the prolongation of the Orleans Railway for about 2½ miles, from its Austerlitz station to a new terminal station on the south side of the Seine at the Quai D'Orsay opposite the Garden of the Tuileries. This road has been built by

tunnelling under the quays along the banks of the Seine. It is to have two tracks from the Austerlitz station to the Boulevard St. Michel, and four for the rest of the way.

The tunnel from the Sceaux Railroad alluded to in the foregoing paragraph will probably be extended from the Luxembourg to the Seine and make use of two of the just mentioned tracks. This line is owned and operated by the Orleans company.

Nearly all of the tunnel along the Seine has been made by the use of shields, by the same process that was employed in building a portion of the Boston subway under Tremont street; *i.e.*, side walls were built in small drifts and the rest of the tunnel excavated and constructed by means of roof shields running on top of these side walls. The walls of the tunnel are constructed in some places of concrete blocks, in others of rubble masonry, employing irregular pieces of hard, gritty stone, known as *meulière*, which is so much employed in rubble-masonry construction in and about Paris.

The double-track portion of this tunnel has an interior width of 9 metres and a height of 5 metres above the rail, which is about 1 foot wider and 1 foot lower than the widest part of the Tremont-street subway in front of the Park-street Church. The contract price for the double-track portion of the tunnel was 1,600 francs per lineal metre, or slightly less than \$100 per lineal foot. This price, however, did not include the cost of changing sewers, water-pipes, etc., nor of the repairs to paved streets, sidewalks, and other structures injured by the tunnelling operations.

The total expense of the prolongation of the Orleans Railway was estimated in round numbers as follows:

For plans and personal expenses	\$180,000
Acquisition of lands and for indemnities	2,460,000
Tunnel construction, including changing of sewers, gas-pipes, etc., required by the work,	3,510,000
All of the constructions above ground, including the foundations of the terminal station	1,850,000
	<hr/>
	\$8,000,000

The fact that the tunnel was by the side of the Seine all the way, which permitted of easily removing the earth and bringing the masonry materials, tended very much to lessen the cost.

The trains, hauled by steam locomotives outside the tunnel, will, between the old Austerlitz station and the new terminal station, be drawn by electric locomotives, the prin-

cial parts of which have already been constructed in America.

This underground road will probably be in operation some months before the opening of the Exposition in Paris.

The principal terminal station covers a space of about 3.7 acres. It will have artistic and architectural characteristics suitable for the position it occupies, which is in one of the most elegant quarters in Paris, on the opposite side of the river from the Tuileries and Louvre and by the side of the Palace of the Legion of Honor. Studies were made by various architects, and the plan adopted was selected by a commission designated by the Minister of Public Works. The exterior of the station will be adorned by several beautiful and costly groups of statuary. A hôtel conducted under the direction of the railroad company will form a part of the structure. There will be an intermediate station at Boulevard St. Michel for passengers with hand baggage only.

The first project for a Metropolitan Underground Railroad in Paris was made in 1856. This and various others from time to time thereafter led to no result. The principal reason why no construction was made was on account of a controversy between the municipal and state authorities as to which should own and control the proposed railroad. In November, 1895, the government consented to consider the so-called Metropolitan as the property of the municipality. Preliminary plans were presented in April, 1897, and in March, 1898, the city of Paris was authorized by law to construct and control the road shown on the plans. The law provided that the municipality of Paris should build the road and replace any of the structures which were injured or changed by the work. The Metropolitan Railroad Company of Paris, incorporated for this purpose, is to lay the rails, furnish the electrical distribution, the rolling stock, and operate the road, assuming all risks without guarantee from the government. It will be noticed that this arrangement is quite similar to that under which the Boston subway was built and let. The present law contemplates about 40 miles of underground railways under various boulevards and streets. The system will comprise a line running from Porte de Vincennes on the east to Porte Maillot on the west, with two branches, making altogether about 9 miles: one running from Porte Clignancourt on the north to Porte d'Orleans on the south; one running entirely around the city, following what is known as the line of the ancient exterior boulevards; and various connecting branches. The line first mentioned is now in course of active construction, and it is hoped that it will (including

the branches) be in operation before the Exposition opens next spring. Its route is by the Cours de Vincennes, Place de la Nation, Boulevard Diderot, Rue de Lyon, Place de la Bastille, streets St. Antoine and De Rivoli, Place de la Concorde, Avenue des Champs Elysées, Place de l'Etoile, and Avenue de la Grand Armée. There is a loop station at each terminal and there are 16 stations between at various prominent points. The distance apart between the stations varies from 1,100 to 3,000 feet. A branch with 3 stations will pass under the Place de l'Etoile and proceed through the Avenue Victor Hugo, the Place Victor Hugo, and the Avenue Bugeaud to the Porte Dauphine. Another branch with 4 stations will pass through the Place de l'Etoile, through the Avenue Kleber to the Place du Trocadéro. The interior of the tunnel is of very nearly the same width and height as the Tremont-street double-track subway in Boston. The width and height of the cars will be each somewhat less than the ordinary Manhattan cars. There are numerous grades of 4 per cent. Curves at the terminal loops have radii of 30 meters. With one exception there is no other curve on this line of less than 75 meters. The basin at the Place de la Bastille is crossed by a bridge. The rest of the line is in tunnel. The walls and roof of the Metropolitan are, in general, of concrete and rubble masonry similar to that already alluded to in the description of the prolongation of the Orleans line. At many of the stations, however, the roof will be composed of steel beams and masonry arches. The tunnelling between the stations is, in general, done by means of roof shields, and the ground is, on the whole, very favorable for this work. At most of the stations the work is done by open cut, and the vehicular traffic at these localities, in the Rue de Rivoli, and other streets of the same width is cut off during construction. The cost was estimated by M. Bienvenüe to be less than a million dollars per mile of double track, including stations, but not including equipment or rolling stock. The stations and tunnel all lie under public ways, no private land being required.

This Metropolitan road was divided into 11 sections. Section 1 was done directly under the direction of the municipal engineers. The others were let to various contractors. All of this work is under the general direction of M. Defrance, who is Administrative Director of Public Ways, Water Works, and Sewers, and under the immediate control of Chief Engineer Bienvenüe and his able assistants.

Taking the Metropolitan and the Orleans lines together, Paris will have in the spring of 1900 some 11 miles of

electric underground railroads in service, and in the early future some 30 miles more.

EAST BOSTON TUNNEL.

Plate 37 of the Fourth Annual Report showed nine different routes for the East Boston tunnel. Further studies have been made on these and other suggested routes. These studies included numerous plans for short tunnels, that is to say, those by which the cars after passing under the harbor from East Boston to Boston proper would reach the surface of the streets at points not far from the junction of Commercial street and Atlantic avenue. Among the terminals on the Boston side for these short tunnels were Commercial street near the North End park, Commercial street near the foot of Hanover street, North street near Richmond street, Hanover street between Prince and Richmond streets, Hanover and Richmond streets via North square, Atlantic avenue and South Market street, Atlantic avenue and State street. The Supreme Judicial Court of Massachusetts decided July 3, 1899, that according to law the bore of the East Boston tunnel should connect at grade with the bore of the present Boston Subway. Since that date the studies and surveys have been confined to tunnels so connecting. Drawings on various scales have been made for the route shown on Plate 4, which route differs but little from Route No. 3 on Plate 37 of the Fourth Annual Report.

One hundred and fifty-seven additional borings have been made during the year ending with the date of this report (Aug. 15, 1899) to assist in further study of the route for this tunnel. The borings have varied in depth from 24 feet to 83 feet. Fifty-four of the borings have been made on land and 103 in the harbor. Additional surveys have been made to determine the widths of streets, locations of buildings, docks, wharves, etc., along various suggested routes.

A test pit about 6 feet long (measured lengthwise of the tunnel) and about 29 feet wide, has been dug at the intersection of Maverick square and Summer street to the proposed depth of the tunnel in that locality. This has revealed the character of the earth there, the amount of water, etc., more clearly than an ordinary boring would do. There has been built in this test pit a full-sized section of the tunnel, 3 feet long, made wholly of concrete. It is proposed to put on this a load of earth much greater than that to be borne by any portion of the East Boston tunnel that is to be built by open cut. Whatever change of shape takes place will be

measured. When the East Boston tunnel is built this slice will form an integral portion of it.

A report by Professor Crosby on the geology of the strata in the vicinity of the proposed tunnel is given in Appendix G.

Study has been made of the later tunnels in Great Britain and elsewhere. Many of them were made with the use of shields and most of those in Great Britain have had their walls made of cast iron. The present price of iron castings in this country is more than sixty per cent. greater than the price eighteen months ago. For this and other reasons, consideration has been given to other methods of construction. The first tunnel under the Thames was built of brick and so was a considerable portion of the unfinished tunnel under the Hudson river. A considerable portion of the Boston subway was constructed of concrete with excellent results both as to strength and economy. The tunnels in Paris for the Metropolitan road and for the extension of the Orleans Railway in that city have been built partly of concrete and partly of a rubble masonry in many respects resembling concrete. It is thought that most or all of the tunnel under the harbor can be made of concrete or of a combination of concrete with rings of steel in a manner that will cost much less than one made of cast iron and be equally useful and have as long a life. With this in view many tests have been made, including some with reference to the effect of salt water on cement and concrete.

The physical conditions in regard to the tunnel are such that the plan of the route between Atlantic avenue and the Boston subway may be varied almost indefinitely without greatly affecting the direct cost. This may enable the Commission to select a route going to some extent under private property where the owners are willing to agree beforehand to a reasonable estimate of damages. The depth of the tunnel is such that if the route should go through private property it would be from ten to twenty feet beneath the sidewalk level, and it does not appear that an easement taken at such a depth would cause more than a nominal injury to any estate in that vicinity. The route shown on Plate 4 may easily be varied so as not to pass through any private property.

Chapter 500 of the Acts of 1897 provides under certain conditions for a subway in Cambridge street connecting with the present Boston subway in Scollay square. A subway for Washington-street traffic has had numerous advocates. In order that the East Boston tunnel when built shall suitably connect with other structures now existing, and with those authorized by law or proposed, and thus form in the

future part of an efficient system, studies have been made showing how such subways may connect with each other. One such study is given on Plate 5. In this case the subway from Cambridge street is shown as having a station underneath the Scollay-square station of the present subway (to be served by elevators) and as continuing down Court street. The arrangement as shown in this study is such that cars may pass without change between Cambridge street and Washington street and between Washington street and East Boston, and so that passengers from either of these branches may connect with the present Boston subway at Scollay square.

Respectfully submitted,

H. A. CARSON,
Chief Engineer.

REPORT OF THE CHIEF ENGINEER FOR CHARLESTOWN BRIDGE.

GEORGE G. CROCKER, CHARLES H. DALTON, THOMAS J. GARGAN, GEORGE F. SWAIN, HORACE G. ALLEN, *Boston Transit Commissioners:*

During the year ending Aug. 15, 1899, the engineering force of the Charlestown bridge has supervised the work under construction, and prepared plans and specifications for all new work undertaken.

CHARLESTOWN APPROACH.

The work on this section of the bridge, under contract at the beginning of the year, has been completed, together with the filling, paving, granolithic walks, and iron and stone railings connected with the same. Doors for the warehouses under a portion of this approach have been contracted for.

Portions of City square and streets adjacent to the Charlestown approach have been raised to new grades, and paved with granite blocks on gravel base.

DRAW FOUNDATION AND FENDER PIERS.

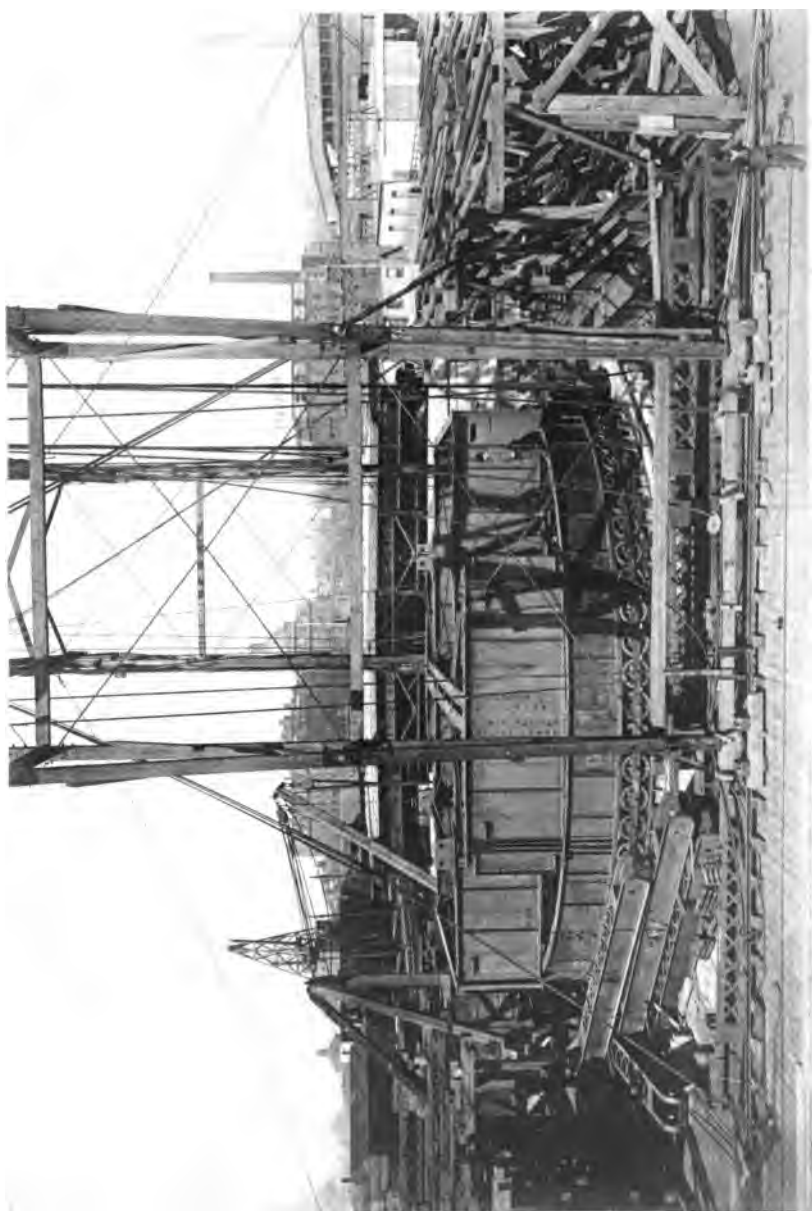
The draw foundation pier and the portion of the fender pier contracted for in 1898 have been completed, and the building of the extension of the fender pier and the removal of the Charles-river bridge have been contracted for with W. H. Ellis, under date of Aug. 10, 1899.

TEN WATER SPANS.

These spans are complete with the exception of a small amount of work to be done to fit roadways and sidewalks to the ends of the draw span.

DRAW SPAN.

The draw span as contracted for by the Pennsylvania Steel Company is completed, and the machinery for turning the draw is in place and works satisfactorily. The draw was first moved on July 6, 1899, by means of hand levers provided for use in case of accident to the electric motors. On Aug. 8, 1899, the electric motors were first used for turning the draw.



TURNTABLE OF DRAW SPAN. MARCH 6, 1899.



DRAW SPAN. MAY 5, 1899.



DRAW SPAN. MAY 11, 1899.

THE HELIOTYPE PRINTING CO., BOSTON.



INTERIOR OF TURNTABLE. DRAW SPAN.

THE HELIOTYPE PRINTING CO., BOSTON.



INTERIOR OF TURNTABLE. DRAW SPAN.

THE HELIOTYPE PRINTING CO., BOSTON.



PORTION OF TURNTABLE. DRAW SPAN.

THE HELIOTYPE PRINTING CO., BOSTON.



ELEVATED RAILWAY STRUCTURE ON BRIDGE.

THE HELIOTYPE PRINTING CO., BOSTON.



STAIRWAY. CHARLESTOWN APPROACH.

THE HELIOTYPE PRINTING CO., BOSTON.

Owing to the failure of the builders to deliver at the agreed time certain portions of the hydraulic plant necessary for adjusting the ends of the draw, it is uncertain when the draw can be put in service.

BOSTON APPROACH.

A contract for masonry walls for the Boston approach was entered into with Woodbury & Leighton in September, 1898, and the work under this contract has been completed, together with the filling, granite paving, brick sidewalks, and iron railing required in connection with this section of the bridge. The grade of the approach is three per cent. The work of raising, paving, and regulating portions of Causeway, Charlestown, and adjacent streets to conform to the grade of the Boston approach was done by Jones & Meehan under contract dated May 10, 1899.

PAINTING.

The finishing coats of paint for the draw span and the ten river spans have been applied by the Buildings Cleaning Company, the paint having been furnished by the Commission.

Respectfully submitted,

WILLIAM JACKSON,
Chief Engineer for Charlestown Bridge.

APPENDIX A.

DECISION OF THE SUPREME COURT IN THE CASE OF BROWNE ET AL. v. TURNER ET AL.

APPLICATION FOR INJUNCTION IN RELATION TO EAST BOSTON TUNNEL.

Decision Rendered July 3, 1899.

HAMMOND, JUDGE. This is a petition under Statute 1898, Chapter 490. At the threshold of the case it is urged by the respondents that the constitutional questions which the petitioners seek to raise are not open to them upon such a petition.

In view of the conclusion to which we have come in relation to the statutory question involved, we have had no occasion to consider the constitutional questions, nor of course whether they can be raised in this way. The statutory question is simply whether the tunnel which the Transit Commission has voted and intends to build is such as Statute 1897, Chapter 500, calls for.

As the first step in this inquiry it is necessary to ascertain what kind of a tunnel the Commission has voted and intends to build. On Oct. 18, 1898, the Commission passed the following vote :

" *Whereas*, The Corporation Counsel has expressed the opinion that, under Section 17 of Chapter 500 of the Acts of the year 1897, this Commission is authorized to build a tunnel or tunnels to East Boston either from the surface at a point on or near Hanover street, or from any subway or subways constructed under the authority of Chapter 548 of the Acts of the year 1894,

" *Voted*, That the construction of a tunnel or tunnels beginning on or near Hanover street, in the city of Boston, or beginning at such other point or points as may be proper for a suitable connection with the subway or subways authorized by Chapter 548 of the Acts of the year 1894, thence running to a point at or near Maverick square in that part of Boston called East Boston, making there a suitable connection with the surface tracks, be proceeded with, and that as a preliminary the Chief Engineer be instructed to have surveys, estimates, and plans made for such tunnel or tunnels."

On Nov. 29, 1898, it

" *Voted*, That route 3-4 be adopted as the route for the East Boston tunnel as far as the vicinity of Atlantic avenue," in the city proper,

and on Feb. 16 and Feb. 23, 1899, it passed the following votes, respectively :

" *Whereas*, The statutes creating this Commission and providing for the construction of the subway and a tunnel to East Boston contemplate a system of public travel to be conducted by street railway cars,

" *Voted*, That, in the judgment of this Commission, a connection by surface street railway tracks between the proposed tunnel to East

Boston and the subway is a suitable connection within the meaning of Section 17 of Chapter 500 of the Acts of 1897.

"*Voted*, That the construction of the tunnel west of the point indicated in the vote of Tuesday, Nov. 29, 1898, shall be such that the tracks shall rise to the surface of the ground by an inclined way."

In addition to these votes the Court has found the following: "The tunnel about to be constructed under the votes set forth in Exhibit 3 will run from Maverick square in East Boston to the junction of Atlantic avenue and Eastern avenue in the city proper, along the route marked 3-4, as shown in Exhibit 2. The Commissioners have come to no definite decision as to the precise direction of the tunnel beyond the last named point, but they are considering the feasibility of bringing the tunnel to the surface on or near Atlantic avenue or Commercial street by means of an incline, or of coming to the surface near North square, or of turning in a southerly direction on Atlantic avenue, and coming to the surface at some point south of the junction of that avenue with Eastern avenue, or of going towards the subway in some other direction."

It thus appears that the easterly terminus is to be at Maverick square, where it will come to the surface by an incline, making there a suitable connection with surface tracks, and that the westerly terminus will be at least as far west as the junction of Atlantic avenue and Eastern avenue in the city proper. Whether it will come to the surface at that point, or at some distance from there, is not definitely decided, but it is certain that it will come to the surface no nearer the subway than North square, which, as appears by the plan, is at least fifteen hundred feet from the nearest point of the subway, and much farther than that from any car entrance to the subway, and that the only connection between the tunnel and the subway is by means of surface tracks.

Is this such a tunnel as the statute calls for? If the statute requires that the tunnel shall make an actual physical connection with the subway, or at least a direct and immediate connection with the subway, so that passengers can pass directly from one to the other, then the question must be answered in the negative. Otherwise it may be answered in the affirmative.

The decision of this question depends upon the interpretation to be given to the following words in Section 17, Statute 1897, Chapter 500: "Whenever said corporation (the Boston Elevated Railway Company) is authorized to begin the construction of its railroad over the route first applied for, as provided in Section 13 of this Act, the Boston Transit Commission shall construct a tunnel or tunnels of sufficient size for two railway tracks, with approaches, entrances, sidings, stations, and connections therefor, and for the running of railway cars therein, from a point on or near Hanover street in the city of Boston or such other point or points as said Board may deem proper for a suitable connection with the subway or subways provided for in Section 25 of said Chapter 548, to a point at or near Maverick square in that part of Boston called East Boston, where a suitable connection with surface tracks may be made."

Simply and briefly stated the question is: Does this language require that the westerly end of the tunnel shall touch the subway, or at least come in direct and immediate connection with it, as above stated?

Inasmuch as the words last above quoted constitute only a part of one section in a statute of several sections, which statute is only one of several upon the same general subject of rapid transit in Boston and its immediate vicinity, it is proper to review to some extent the prior legislation on this matter and further to see what was the actual condition of things, physical or otherwise, at the time of the passage of the Act, so far as material to this inquiry.

The first Act authorizing the construction of a subway was Statute

1893, Chapter 478. Section 1 provided that the Mayor of Boston should appoint a Board of three subway commissioners. By Section 2 this Board was authorized to lay out and construct for street railway purposes a subway with approaches, stations, exits, and entrances from a point or points at or near the junction of Tremont and Pleasant streets to Scollay square, and to other streets near Scollay square, to a point or points where, in the judgment of the Board, a suitable and advantageous exit to connect with surface tracks might be obtained. By Section 3 authority was given to the Board to take lands either below or upon the surface as might be requisite for the widening of the subway and for suitable approaches thereto and extension thereof to connect with surface tracks and for suitable stations, exits, and entrances. By Section 7 power was given to the Board to compel the cars of any lines of street railway running in and through said city to run in and through the subway.

It is manifest that this statute contemplated a physical union between the entrances to and exits from the subway and the surface tracks, and the Commission was authorized to take such "lands either below or upon the surface" as might be requisite for widening the subway and for suitable approaches thereto and extension thereof to connect with those tracks. In other words, they were authorized to build the subway and to extend the approach so as to make connection with the surface tracks.

The next statute is Statute 1894, Chapter 548. The title is, "An Act to incorporate the Boston Elevated Railway Company and to promote rapid transit in the city of Boston and vicinity." The first twenty-two sections provide for the incorporation of the Boston Elevated Railway Company and authorize it to build an elevated railroad over certain routes therein specified and to lease and purchase certain street or elevated railway lines. The remaining sections provide for the appointment of the Boston Transit Commission, consisting of five persons, and for the construction of subways and a tunnel.

Section 25 authorizes the Commission "to construct in the city of Boston a subway or subways of sufficient size for four railroad tracks, with approaches, entrances, sidings, stations, and connections therefor, and for the running of railway cars thereon, through and under Tremont street and the adjoining mall of Boston Common and through public and private lands adjoining on said street, from a point or points within one thousand feet of the junction of Tremont street and Shawmut avenue to, through, and under Scollay square," and "to a point or points on Washington street, or between Scollay square and Causeway street."

By Section 26 the Commission was authorized to "construct a tunnel or tunnels of sufficient size for two railway tracks, with approaches, entrances, sidings, stations, and connections therefor, and for the running of railway cars therein, from a point on or near Scollay square in the city of Boston, where a suitable connection may be made with the subway or subways provided for by this act, to a point on or near Maverick square, in that part of Boston called East Boston, where a suitable connection with surface tracks may be made."

Section 27 authorized the Commission to construct subways from Tremont street "to a point on or near Boylston street, where a suitable connection with surface tracks may be made;" and another subway from Boylston street, "to a point or points on or near Columbus avenue, where a suitable connection with surface tracks may be made;" also another subway from Tremont street "to a point on or near Staniford street or Merrimac square, where a suitable connection with surface tracks may be made."

By Section 29 the Commission "may locate and construct said subways, tunnels, approaches, tracks, sidings, stations, entrances, and connections where it deems best within the limits aforesaid," with certain exceptions not here material; and by subsequent sections full power to take lands, either above or below the surface, is given for the purpose

of doing the work. By Section 35 the Commission was authorized to grant locations for tracks to and for two tracks in said subways and tunnels, to be used by any street railway company or companies.

It will be observed that the Commission is to construct not only the subway proper, but also approaches, entrances, sidings, stations, and connections therefor, and for the running of railway cars. That is to say, it is to bring the bottom of the subway to the surface of the ground, extending it far enough to make the connection between the subway tracks and the surface tracks, or, in other words, the point of connection from the subway side must be reached by the work which the Commission is authorized to do, while the point of connection from the other side must be reached by the street railway company; and the work of both is to constitute a continuous track or a foundation therefor.

All this means an actual physical connection between the track which the Commission is authorized to construct and the rest of the track, and the Commission is to make the connection, that is, the approach to the tunnel is to be extended far enough to reach the surface tracks. There is to be no intervening space between the extension of the subway and the ground where the surface tracks are laid, the ends of which are to connect with the ends of the subway tracks. The language is always the same, and it is obvious that it means an actual physical connection.

As to the tunnel authorized by Section 26, the language is precisely the same as to the appurtenances connected with the tunnel and as to the connection with surface tracks at its easterly terminus, and of course it must have the same construction. But as to the westerly end the Act says that the start must be made "from a point on or near Scollay square . . . where a suitable connection may be made with the subway or subways provided for by this act." These subways were all connected, and a connection with the subway at Scollay square was all that was needed to enable the traveller to reach any point in any of these subways. The nature of that connection will be considered hereafter.

Statute 1895, Chapter 440, and Statute 1896, Chapter 492, are not material to this inquiry and may be passed over without further notice.

We now come to Statute 1897, Chapter 500, which contains in Section 17 the language to be construed. It is entitled, "An Act to promote rapid transit in the city of Boston and vicinity." The most of its provisions concern the location and construction of the Elevated Road. But Section 5 provides that whenever the Boston Elevated Railway Company "shall request said Boston Transit Commission or the city of Boston to construct a subway in and under Cambridge street . . . to connect with the subway now being constructed by said Commission . . . said Commission shall forthwith construct an incline, open cut and subway, beginning at a point on Cambridge street," etc., and running "to a junction at Scollay square with the subway."

Section 18 makes an additional appropriation for the payment of the costs and expenses of the subways and tunnel.

Between the passage of the Act of 1894 and that of 1897 much progress had been made in the subway construction, and a contract had been made between the city of Boston, acting by the Boston Transit Commission, and the West End Street Railway Company (to whose rights the Boston Elevated Railway afterward succeeded), by which the right to use and occupy the subways and tunnel constructed or to be constructed under the then existing statutes was granted to the street railway company, such use to be only for the location of the tracks of the company, and for the operation of its railway for the purposes enumerated in the contract. Before August, 1897, and probably early in the spring, that portion of the subway extending from the entrances in the Public Garden and from those at Pleasant street to Park street was nearly completed, and the lessee was engaged in laying its tracks therein.

In the spring of 1897, prior to the enactment of Chapter 500 of the Acts of that year, the subway was under construction in Cornhill between Scollay square and Washington street, in Hanover street between Scollay square and Washington street, and in Washington street between Adams square and Haymarket square, and the subway has since been completed along this route from Scollay square to Travers street. At this time the East Boston cars tapped Washington street at Hanover street.

By agreement of parties it also appears:

"1. That such tunnel as the Transit Commission is proceeding to construct can be built within the sum now available for tunnel construction, which is \$2,634,000.

"2. That the estimated cost of such a tunnel as the Boston Transit Commission is about to construct is about \$2,500,000.

"3. That a tunnel from a point on or near Scollay square, or from any point on the subway as now existing, to Maverick square, cannot now and could never have been built for any sum available for tunnel construction under the Statute of 1894 or the Statute of 1897. The estimates of the cost of such a tunnel are between \$3,000,000 and \$4,000,000. The cost of the subway as now constructed is about \$4,250,000.

"4. That a tunnel from a point on or near Scollay square, or from any point on the present subway, to Maverick square, is materially longer and more expensive than a tunnel from any point northerly of the subway on or near Hanover street or Atlantic avenue, such as is proposed to be built.

"5. That some portions of the subway authorized by Statute 1894, Chapter 548, viz., space for two additional tracks between Scollay square and Park street and between Boylston street and Shawmut avenue, have not yet been built; but no action has been taken by the Commission looking to the construction under said Act of any addition to the subway as now existing.

"6. That the only connection between the proposed tunnel and the subway, such that cars can pass from one to the other, will be by means of tracks run along the surface from the terminus of the tunnel to the entrance of the subway near Causeway street.

"7. That the distance from the intersection of Commercial street and Eastern avenue to the entrance of the subway at Causeway street is about 4,366 feet; that the distance from said intersection to the junction of Hanover and Washington streets, via Fleet street and Hanover street, is about 2,517.5 feet, and via Commercial and Hanover streets about 3,346 feet.

"8. That said balance of appropriation is not sufficient to connect the tunnel with the subway by any underground structure so as to make a connection at grade and to let cars pass immediately from the tunnel into the subway and *vice versa*.

"9. That the Boston Elevated Railway Company entered into an agreement with the city of Boston, dated Dec. 15, 1897, a copy of which is hereto annexed and marked 'Exhibit 4.'

"10. That prior to April 1, 1897, the portion of the subway north of Scollay square was under construction in Cornhill, in Hanover street between Scollay square and Washington street, and in Washington street between Adams square and Haymarket square.

"12. That in the spring of 1897, prior to the enactment of Chapter 500 of the Acts of that year, the subway was not completed; the tunnel was not begun; it was estimated by the Transit Commission that the subway would cost \$5,000,000; that a tunnel to East Boston from a point on or near Scollay square, or from the point of the subway nearest to Maverick square, could not be built for the amount then remaining available for a tunnel from the construction of the subway; and that a shorter tunnel, from a more northerly point on or near Hanover street,

could be built for \$2,406,000, as appears by an estimate on page 14 of the Report of the Transit Commissioners, dated Aug. 15, 1896."

And the Court has found that "the appropriation available for the tunnel is sufficient to construct it with an incline from the said last-named junction (the junction of Atlantic avenue with Eastern avenue) to a point on North square or to a point south of said junction, but not to a point nearer the present subway than North square."

We do not think the fact that a copy of the report made by the Boston Transit Commission to the City Council of Boston, containing an estimate of \$2,406,000 as the cost of a tunnel from Maverick square, East Boston, to a point on Hanover street, along the route marked as Route 1 on "Exhibit 2," was mailed to the members of the Legislature soon after their election, can affect the construction to be given to the language under discussion. The report was not made to the Legislature, was doubtless only one of many documents and papers sent to the different legislators while in office, and we cannot assume that any member read it, or that if he did he paid any particular attention to Carson's estimate, which was contained in only a few lines, or that if he did pay any such attention he was at all influenced by the estimate in voting upon the bill. Nor would the statement of any member that he was so influenced be admissible, nor even what he supposed the bill meant. Certain general facts of common knowledge, such as some of those agreed upon in this case, may, however, be taken into consideration under a principle similar to that under which, in construing a private contract, the circumstances may be shown to enable the Court to see the situation of the parties. In the light of this previous legislation and of these circumstances we are to interpret the language of the statute.

The first contention of the Commission is that the language does not require that the terminal point in the city must be one which the Board may deem proper for a suitable connection with the subway. They submit that two distinct termini are permitted, first, at a point on or near Hanover street in the city of Boston, without reference to any connection with the subway; and second, such other point or points as said Board may deem proper for a suitable connection with the subway, and that the limitation that the point shall be suitable for a connection with the subway is not attached to the first terminus. But the suggestion is not much pressed, and it does not seem to us to require much discussion. The whole scope of the legislation upon the subject shows that this tunnel is to be regarded as a substitute for the tunnel authorized by Statute 1894, and as one of the features of the plan of rapid transportation therein provided for. To interpret the language as giving to the Commission the power to construct a tunnel which would have no relation to this plan would be out of harmony with the general nature of the legislation and with the general purpose for which the Commission was established and the general nature of the authority conferred upon it.

It must be conceded that the sentence under discussion is loosely constructed, but disregarding punctuation, as may properly be done (*Cushing v. Worrick*, 9 Gray, 385; *Martin v. Gleason*, 139 Mass. 187), and bearing in mind that the presumption is that every word of a statute is to have some force and effect (*Opinion of the Justices*, 22 Pick. 571-573), so that in this case the word "other" must be supposed to have some office, and considering above all the general scope of the legislation in which the authority to construct the tunnel is found and the general nature of the authority conferred upon the Commission by whom it is to be constructed, we have no doubt that the clause "as said Board may deem proper for a suitable connection with the subway" refers as well to the point "on or near Hanover street" as to the other "point or points." The westerly end of the tunnel, therefore, must be at some point which the Commission "may deem proper for a suitable connection with the

subway." The Commission has voted that that point shall be many hundred feet from any point of the subway, and that a connection by surface street railway tracks is a suitable connection.

The petitioners contend that the connection between the subway and tunnel must be an actual physical connection, that the tunnel must go to the subway, and that a connection by the track of a street railway several hundred feet in length is not such a connection as the statute calls for.

The point is to be selected by the Commission, and it must be a point where a suitable connection may be made with the subway. That point cannot be fixed until the kind of connection required by the statute is first determined.

What is meant by the word "connection" as here used? The word is used in various places in the preceding statutes on this same subject to which we have referred. Where it refers to surface tracks it means, as we have heretofore said, an actual physical connection with such tracks. Or, in other words, where there is to be a connection with surface tracks the Commission shall extend the entrance to the subway far enough to reach surface tracks, and it is authorized to take land enough for the purpose, and there is to be no intervening land between that upon which the subway rails rest and that upon which the surface rails rest. The rails are to meet physically. The authority of the Commission upon the subway side of the point of meeting goes to that point; the authority of the surface road, on the other side, extends to that point, and there is no intervening link, no intervening authority.

This tunnel is to have two ends, the easterly end in Maverick square and the westerly in the city proper. The easterly end is to be carried to a point where a suitable connection with surface tracks may be made. This language is the same as that used with reference to the subway and must receive the same interpretation. That is to say, the tunnel is to rise to the surface and the approach is to be extended far enough to reach the surface tracks, and to that point the tunnel must go. The manner of making the connection and the details are left to the Commission, but the order to the Commission is to go far enough to make such a physical connection. There must be no intervening rail between the tunnel rail and the rail of the surface road.

The westerly end is to be at some point where a suitable connection may be made with the tunnel. Here, then, is the same phrase, "suitable connection." Wherever we have heretofore met it in these statutes we have seen that it means an actual physical contact. Indeed, with reference to the other end of this same tunnel, it has that meaning. One of the most familiar rules relating to the interpretation of statutes is that a word or phrase repeatedly used in the same statute is presumed in the absence of a clear intent to the contrary to have the same meaning throughout, and amending statutes are to be regarded as a part of the original statute within the meaning of this rule.

It is to be observed that the connection is to be made by the Commission, and we can see no sound reason for making a distinction as to that duty at the different ends of the tunnel. As at the easterly end the tunnel must be extended far enough to make a physical connection with the surface tracks, so at the westerly end it must go far enough to make a physical connection with the subway; and as at the easterly end there must be no intervening link between the tunnel side and the surface-track side of the point of connection, so at the westerly end there must be no intervening link between the tunnel side and the subway side of the point of connection. The tunnel must go to a point where such connection may be made, and the Commission must make the connection. The Commission also constructs the subway. Its authority, therefore, on both sides on the point of connection is exclusive, and there must be no intervening power. The connection is to be made complete by their authority.

This is the most natural construction of the statute, when read in the light of the previous legislation upon the same subject and of the circumstances existing at the time it was passed. Any other construction seems to us not only forced and unnatural when considering the statute by itself, but also entirely inconsistent with the main purpose of the entire body of laws of which this is a part; namely, to secure rapid transit in Boston and vicinity and to reduce the congestion in the streets by means of a system of subways and tunnels:

But the respondents urge that no such tunnel as is called for under this construction of the statute can or ever could be built with the sum already appropriated, while the tunnel which the Commission has voted can be built within the appropriation. This fact does not seem to us of much weight. It is a matter of common knowledge that the actual cost of a public work frequently exceeds the estimate, and that appropriations are made from time to time as needed, especially where considerable time is to be taken in its construction.

The change in the westerly end of the tunnel, from Scollay square to Hanover street or some other point, is accounted for by the fact that between the passage of the two Acts the subway had been extended to Hanover street and elsewhere so that it was no longer necessary to build the tunnel to Scollay square to reach it. Besides, to reach the square it might be necessary to cross the tunnel in process of construction on Washington street.

We hold, therefore, that the connection between the westerly end of the tunnel and the subway is to be an actual physical connection, and that the tracks between them must come to the same grade at the point of junction.

Upon this construction of the statute it is manifest that the Commission is not authorized to construct the tunnel which it has voted to build.

Decree for plaintiffs.

APPENDIX B.

CAPACITY OF THE SUBWAY.

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, April 13, 1899.

To the Honorable the Speaker and the House of Representatives of the Commonwealth of Massachusetts :

The Boston Transit Commission respectfully submits its reply to the following order passed by the House of Representatives and received by the Commission at its meeting on April 11 :

“*Ordered*, That the Boston Transit Commission be requested to inform the House of Representatives forthwith whether the subways leased to the Boston Elevated Railroad Company are now being used by said company to the full capacity thereof, especially at the Park-street station, and, if not, in what manner and to what extent said subways may be more fully utilized and travel therein expedited.”

The first question is whether the subway is now being used to its full capacity, especially at the Park-street station.

There are three sets of tracks in the subway. One set enters at the Boylston-street incline and forms a loop at Park street. The second set consists of the through tracks running from Pleasant street to Travers street. The tracks of the third set enter the subway at Travers street, pass up Hanover street to Scollay square and return again to the northern exit by way of Cornhill and Washington street.

The loop tracks are at various points connected with the through tracks by switches for the convenient transfer, when desired, of traffic from the one to the other. At the northern terminal these switches are controlled from an interlocking tower.

Inasmuch as the tracks within the subway are free from the interference which surface tracks suffer from foot-passengers, from teams, and from grade crossings, it is obvious that between stations the subway tracks have a greater capacity for traffic than surface tracks.

What is the capacity for traffic at the subway platforms?

Last fall during the first two months or so of the operation of the subway as a whole the traffic on the Park-street loop was delayed at the Park-street platforms, and the public inadequately accommodated. The Elevated Railway Company, however, soon initiated changes in the method of operation adapted to the requirements of the situation. These changes consisted in increasing the number of berths at the platforms and in notifying passengers in advance as to the exact point at which each car was to stop.

On December 9 last, before these changes were fully developed, it was found that 195 cars passed around the loop at Park street in the hour of maximum traffic, that is, between five and six o'clock in the afternoon. This traffic did not result in congestion of cars within the subway.

The card indicator then in use could be seen only from a portion of the platform. Electric indicators at each end of the platform, readily visible from all parts of the platform, and from the stairs as well, have since been installed, and the method of handling the traffic has in other respects been materially improved.

Since the said 9th December, 1898, this Commission has had counts made of the number of cars passing over tracks in the subway in the maximum hour on a few days only. The following is the result of these counts so far as the Park-street loop tracks are concerned:

Thursday, Dec. 15, 1898	176
Wednesday, Jan. 18, 1899	187
Wednesday, March 29, 1899	155
Thursday, March 30, 1899	175
Tuesday, April 4, 1899	181

It is evident that if, with the only partially developed methods of handling passengers and cars in use on Dec. 9, 1898, 195 cars per hour could be handled without congestion, the improved methods of operation now in use will permit the running of a larger number of cars, and that the limit of traffic capacity on these tracks has not been reached. Admirable as are the present methods of operation, there is opportunity for still further improvement in the future.

Complaint has been made in regard to the crowding which has occurred on the Park-street platform in the eagerness of people to get on board the loop cars. Before the present methods of operation were adopted, this crowding was most objectionable and in many cases dangerous. The chief cause of the trouble was that no passenger knew where his car was going to stop until it appeared at the platform. The distribution of passengers, therefore, to the several cars had to take place practically after the arrival of the cars, and people who were at one end of the platform hurrying to the other to get their car caused much confusion, excitement, and hustling. While there are still people who have not learned to avail themselves of the information furnished by the electric indicators, it is believed that the difficulty above referred to is now practically remedied. It was a difficulty which was foreseen by the Commission before the plans of the subway were adopted and its solution was then worked out on the line of the device now in use.

It must be borne in mind that if there are more people desiring passage on a car than there are seats within it, they will, in their eagerness to take that particular car and to get a seat, crowd towards and upon the car platforms, no matter how large may be the open space around the car.

So far as the other two sets of tracks in the subway are concerned, the number of cars requisite for present traffic does not utilize them to their full capacity. Each of these two sets has at least as great a capacity for traffic as the Park-street loop. The through tracks are now carrying about three-fifths as much traffic as is carried on the Park-street loop, and the traffic on the Scollay-square loop is still less.

The answer to the first question is, therefore, that the subway is not now being used to its full capacity.

The next question is in what manner and to what extent the subway may be more fully utilized, and travel therein expedited.

The subway is utilized at the present time to the extent of the business which is brought to it. It is capable of doing more business when more business is offered. If congestion in any part should occur in the future, relief should be sought, as it has been sought at the Park-street station, by improved methods of operation, and also by transferring traffic from the overburdened tracks or portions of platforms to those less heavily loaded.

The subway was carefully planned to avoid all grade crossings by cars going in different directions, but it was also planned with special reference to facilitate the transfer of traffic between tracks for cars going in the same direction.

The problems of operation which occur within the subway are not the

same as those which occur on the surface, and it was not to be expected that they would be correctly solved at once, or that the full benefits of the island platforms would be immediately developed.

The present method of taking up tickets and transfer checks in the cars in the subway is a source of considerable delay to traffic and inconvenience to passengers. This system is particularly prejudicial to rapid transit where the stations are so near together as they must necessarily be in the very heart of the city. If the company could devise some method to avoid these delays by taking tickets from passengers as they enter the subway, according to the system in use on the New York Elevated Railway, much would be accomplished towards promoting rapid transit, the convenience of the public would be increased, the transfer turnstiles and barriers at the Park-street platforms would be unnecessary, the special stop for the transfer station at Park street would be done away with, and passengers could have the choice of several platforms at which they could transfer instead of being limited, as at present, to those particular platforms specially arranged for transfer service.

It is recognized that it is not a simple matter to carry out this suggestion consistently with the operation of cars outside of the subway, but it is believed that the problem can be solved, and that it is not more difficult than other problems which have been solved by the company in its efforts to promote rapid transit.

THE BOSTON TRANSIT COMMISSION,

By GEORGE G. CROCKER,

Chairman.

APPENDIX C.

HISTORICAL STATEMENT IN RELATION TO CHARLESTOWN
BRIDGE, PREPARED BY THE CHAIRMAN OF THE COM-
MISSION.

THE FERRY — 1630 TO 1785.

At a Court of Assistants holden at Boston, Nov. 9, 1630, it was ordered :

"That whosoever shall first giue in his name to Mr. Goûnr that hee will vndertake to sett vpp a fferry betwixte Boston and Charlton, & shall begin the same att such tyme as Mr Goûnr shall appoynt, shall haue 1^d for eûy pson, & 1^d for eûy 100 waight of goods hee shall soe transport."

June 14, 1631, the following entry was made :

"Edw: Converse hath vndertaken to sett vpp a fferry betwixte Charlton & Boston, for which hee is to haue ij^d for eûy single pson, & 1^d a peece if there be 2 or more."

On the 2d of Nov., 1637, the ferry between Boston and Charlestown was referred to the governor and treasurer to be let at forty pounds per annum, beginning with the 1st of December, and from thence for three years. On the 28th of Nov., 1637, the ferry was so leased to Edward Converse.

At a meeting of the General Court held on the 7th of Oct., 1640, the ferry between Boston and Charlestown was granted to Harvard College.

At a session in October, 1644, it was ordered that the passages over this ferry of magistrates and deputies of the Court with their necessary attendants shall be free and two years later it was declared that by necessary attendants was meant a man and horse, and not the families of magistrates and deputies.

In 1650, in answer to the petition of its president, Henry Dunster, the college was given power to dispose of the ferry by lease or otherwise.

From the college records of a meeting on the 7th April, 1713, it appears that a motion had been made in the General Court for building a bridge at the ferry between Boston and Charlestown, and it was voted that the president and treasurer be desired to represent and to insist upon the right which the college hath in and to the profits of the said ferry.

This was probably the first official suggestion of the desirability of building a bridge to take the place of the ferry.

For many years after the ferry was established, only one boat was used. Afterwards two boats were put in service, one being kept on each side of the river, and in the year 1781 a statute was passed requiring an equipment of four boats.

In 1785 John Cabot and others presented to the Legislature a petition asking for the privilege of building a bridge from Lechmere point in Cambridge to Barton point in Boston, and the petitioners stated that they would agree to pay two hundred pounds annually to Harvard college so long as they were authorized to collect tolls on said bridge. This petition was opposed and defeated by Thomas Russell and others, who asked for the privilege of building a bridge over Charles river between Boston and Charlestown, "where an ancient ferry had been established."

CHARLES-RIVER BRIDGE — 1785 to 1899.

By an act passed on the 9th March, 1785, the General Court granted this petition, and John Hancock, Thomas Russell, and others were incorporated as the proprietors of Charles-River Bridge.

The following is the schedule of tolls established by the third section of the Act — viz. : "each foot passenger (or one person passing), two-thirds of a penny; one person and horse, two pence two-thirds of a penny; single horse cart or sled, or sley, four pence; wheelbarrows, hand-carts, and other vehicles capable of carrying like weight, one penny, one-third of a penny; single horse and chaise, chair or sulkey, eight pence; coaches, chariots, phaetons and curricles, one shilling each; all other wheel carriages or sleds drawn by more than one beast, six pence; neat cattle and horses passing the said bridge, exclusive of those rode or in carriages or teams, one penny, one-third of a penny; swine and sheep, four pence for each dozen, and at the same rate for a greater or less number; and in all cases the same toll shall be paid for all carriages and vehicles passing the said bridge, whether the same be loaded or not loaded; and to each team one man and no more shall be allowed as a driver to pass free from payment of toll, and in all cases double toll shall be paid on the Lord's day; and at all times when the toll gatherer shall not attend his duty the gate or gates shall be left open."

The bridge was required to be at least forty feet wide, with a draw opening at least thirty feet wide. This draw was to be opened, and ships and vessels were to be permitted to pass free of toll, "except such as usually pass under Cambridge

bridge, and those passing for pleasure." The Cambridge bridge here referred to was the bridge crossing the Charles river near the college, connecting Cambridge with what is now the Brighton district of Boston.

It was required that there should be twenty good lamps on each side of the bridge, which should be kept well supplied with oil, and should be lighted in due season and kept burning until twelve o'clock at night.

It was further provided that the corporation should make an annual payment to the President and Fellows of Harvard College of two hundred pounds, and that at the end of the term of forty years the bridge should be left in good repair, and should revert to the Commonwealth, "saving to the college a reasonable annual compensation for the annual income of the ferry which it might have received had not the bridge been erected."

The bridge was rapidly constructed and was opened for traffic on the seventeenth of June, 1786. This was the first bridge connecting Boston with the mainland; the only road into Boston up to that time being the road through Roxbury and over the Neck.

The opening of the bridge was regarded as a most important event, and a few days later was thus described in somewhat exalted phrase in the "Independent Chronicle and Universal Advertiser," and almost in the same words in the "Massachusetts Centinel":

Saturday last was observed as a day of rejoicing, occasioned by the proprietors opening the new bridge over Charles river. This commodious and handsome structure is 1,470 feet in length and 42 feet wide within the paling. This bridge has been completed in thirteen months, and whilst it exhibits the greatest effect of private enterprise within the United States, is a most pleasing proof how certainly objects of magnitude may be attained by spirited exertions.

The design of opening the bridge on the seventeenth of June, it was natural to suppose, would combine the most agreeable sensations, and it is certain that but few were disappointed. As the directors made every exertion to secure uninterrupted festivity on the day, and it fortunately happened that the weather was peculiarly agreeable, all orders were accordingly gratified and every face exhibited genuine marks of unfeigned hilarity. Those who were rather struck by the convenience of the thing were abundantly pleased in exchanging the precarious conveyance of a ferry for the more expeditious and agreeable passage of a firm and respectable bridge, which affords all the benefits without any of the inconveniences to which the other is exposed. Those who know no other pleasure but the contemplation of their interest, were many of them apparently anticipating the golden harvest which the immense numbers would afford, that either business or amusement will lead to improve this commodious inlet, while those who were warmed by sentiment, or inspired by patriotism, almost wept at the recollection of the different scenes that the immortal epoch, of which this was the anniversary, had exhibited. It was impossible, indeed, to have been present and not to have been affected by the striking contrast of the two periods.

The company invited moved in procession from the State House precisely at one o'clock, in the following order :

The Charlestown Company of Artillery under Captain Calder,
 One Hundred and Twenty Artificers who had been employed on the
 bridge, carrying their different tools,
 The directors and proprietors of the bridge,
 The Vice-President and Treasurer,
 A band of music, accompanied with drums and fifes,
 The President of the proprietary,
 The Sheriffs of the counties of Suffolk and Middlesex,
 and the flanks guarded by under-sheriffs of the two counties and
 constables.
 His Excellency Governor Bowdoin and
 His Honor Lieutenant Governor Cushing,
 The Council of the Commonwealth,
 The President and Senate,
 The Speaker and members of the House of Representatives,
 Treasurer and Secretary of the State,
 Consuls of France and Holland,
 Judges of the Supreme Judicial Court and
 Attorney General,
 Naval and Excise Officers,
 President and Corporation of the University,
 Clergy,
 Professors and tutors of the University,
 Chairman and Selectmen of Boston,
 Selectmen of Charlestown,
 Overseers of each town,
 Commander of Castle William and
 Officers of the late Continental Army,
 President and Directors of the Massachusetts Bank,
 A great body of private gentlemen,
 Foreigners and citizens.
 A body of Civil Officers closed the procession.

Thirteen cannon were discharged from Copp's hill, while they were passing the bridge. It is computed that at least 6,000 people, besides horses and carriages, were upon it at the same moment.

No one that remembered the confusion and horror with which the battle of Bunker Hill was attended,—the town of Charlestown in flames,—and all assistance precluded by the astonishing fire of artillery,—the movements of the hostile armies, with their dreadful apparatus,—the fatal crackling of the musketry,—the wounded and dying carried off by their friends,—and the apprehensions seated on every brow lest the final period of American liberty had approached, could be an uninterested spectator of the joyous scenes which were now everywhere presented. The streets, the windows and eminences in the neighborhood of the bridge swarmed with spectators to the amount of at least twenty thousand, and the ladies were peculiarly attractive. An elegant dinner for eight hundred persons was provided at the expense of the proprietors.

Then follows an account of the dinner and a list of some thirteen toasts to the United States, the Governor and Commonwealth, the Allies of America, etc. ; after which an ode was sung.

The account closes as follows :

Joy crowned the day, and in the evening the lamps were lighted on the bridge, and produced not only a happy effect on the eye, but were

very useful in directing the steps of some of the votaries of the rosy deity who returned to town between ten and eleven, with a band of music before them, inspired by the collective pressure of the scene, but above all by the generous draughts they had taken to commemorate this auspicious occasion.

The capital stock of the proprietors of the Charles-river bridge consisted of 150 shares of the par value of £100 each, making the total capital stock £15,000, or about \$75,000. The architect of the bridge was Major Samuel Sewall.

The population of Boston at this time was 17,000 and of Charlestown 1,200.

The "Massachusetts Centinel" of 5th July, 1786, states that a count made on the preceding June 21st showed that the traffic over the bridge on that day, exclusive of foot passengers and cattle, was as follows :

Between sunrise and sunset				£.	s.	d.
20 coaches	.	.	at 1s.	1	0	0
135 chaises	.	.	" 8d.	4	10	0
137 carts	.	.	" 4d.	2	5	8
193 horses	.	.	" 1½d.	1	1	5½
In evening						
15 chaises	.	.	" 8d.	0	10	0
<hr/> 500				<hr/> 9 7 1½		

It appears that at first the bridge was exceedingly profitable, paying for several years a profit of from thirty to forty per cent. Josiah Quincy, the grandfather of the present Mayor, in his most interesting and instructive recollections of "Figures of the Past" states that in 1826 an original proprietor of a single share had received back not only the principal of his investment with interest, but also a surplus of \$7,000.

On the 9th March, 1792, an act was passed incorporating Francis Dana and others as the proprietors of the West Boston bridge, with authority to build a bridge from a point in Boston near the Pest House to Pelham's island in Cambridge. This corporation was given rights to collect tolls similar to those given to the Charles River Bridge Corporation and was required to make annually a payment of £300 to Harvard College to defray the expenses of the tuition of indigent scholars and for other specified purposes. The other provisions of the act were modelled after those of the act relating to the Charles-river bridge.

By urging that the construction of this bridge would seriously diminish their income the proprietors of the Charles-river bridge succeeded in securing an extension of their privileges for thirty years, making seventy years in all, and

in partial consideration therefor were required to relinquish their right to take double toll on the Lord's day. The extension of term was made with the proviso that the payment of £200 should be made annually during the term to Harvard College.

By act of 20th June, 1803, the width of the Charles-river bridge at the draw was permitted to be thirty feet instead of forty-two feet, which was the width of the rest of the bridge.

In 1807 the General Court authorized the building of the Canal bridge from Leverett street to Lechmere point, which bridge is now known as the East Cambridge or Craigie's bridge.

In Hale's "Survey of Boston and its Vicinity," published in 1821, after describing the one road over the land leading to Boston over the Neck, and the South Boston, the West Boston, Craigie's, and Charlestown bridges, it is stated that the principal leading streets from these avenues are generally of good width, except that from the Charlestown bridge, which is irregular and too contracted for carriages, and in fact the whole northern section of the town stands in need of some general system of modernization.

On the 17th June, 1825, a brilliant civil and military procession, escorting General Lafayette and other survivors of the Revolutionary Army, and Daniel Webster, the orator of the day, passed over the Charles-river bridge to lay the corner-stone of Bunker Hill Monument.

In 1828 certain parties petitioned the General Court to be incorporated as the Warren Bridge Corporation. This petition was strenuously opposed by the proprietors of the Charles-river bridge, who offered to widen their own bridge to sixty or eighty feet, and also to relieve the delay and inconvenience occasioned by raising the draw by constructing a circular draw so that travellers should not be delayed or impeded while actually passing over their bridge. In spite of their efforts, however, the act incorporating the Warren Bridge Corporation became a law on the 12th March, 1828. (Acts 1827, chap. 127.)

The section of the act relating to tolls was similar to that in the act relating to the Charles-river bridge, but the provisions with reference to the length of term of the franchise were far different. These provisions were as follows: "When said proprietors shall be reimbursed the money expended in building the bridge and necessary expenses with five per cent. interest the property shall revert to the Commonwealth, provided that the term of taking the tolls shall not exceed six years." Until such reversion to the Common-

wealth the corporation was required to pay to Harvard College one-half of the sum required to be paid by the proprietors of Charles-river bridge, who were to that extent released from their obligation.

Upon the passage of this act the proprietors of the Charles-river bridge appealed to the courts, praying for an injunction against the building of the proposed bridge, or, in default thereof, for general relief. Their counsel were Daniel Webster and Lemuel Shaw, who subsequently became Chief Justice of our Supreme Court. Notwithstanding the consummate skill, the great learning, and the repeated efforts of these leaders of the bar, the defence was successfully conducted by Messrs. Fletcher and Aylwin, and the bill of the complainants was finally dismissed. (6 Pick. 376; 7 Pick. 344.) The importance of this case may be realized from the fact, which appeared in evidence, that the aggregate of tolls collected on the Charles-river bridge from its opening in June, 1786, to January, 1827, was \$824,798, and that the new Warren bridge so soon as opened took two-thirds of this traffic. Nor was this the worst. The Warren bridge was to revert to the Commonwealth at the end of six years and might then be made free, with the result that all income from the Charles-river bridge would thereupon cease, some twenty years prior to the termination of its charter rights.

Seeing that the value of their hitherto exclusive franchise was suddenly greatly impaired and would soon be utterly destroyed, the stockholders of the Charles-river bridge fought with desperate earnestness for what they believed to be their vested rights. Having finally failed in the State courts, they carried their case by writ of error to the Supreme Court of the United States. There again they were unsuccessful. In 1837, nine years after the original bill in equity was brought in Massachusetts, the judgment of our Supreme Court was affirmed by the Supreme Court of the United States. (11 Peters, 420.) The report covers 230 pages. Justices Story and Thompson dissented, the dissenting opinion being written by Mr. Justice Story.

As at the beginning of this litigation the State court had refused to issue even a temporary injunction, the Warren Bridge Corporation pushed forward construction with the greatest expedition and on Dec. 25, 1828, the bridge was opened for travel.

In March, 1836, the Warren bridge became free. Thereupon the proprietors of Charles-river bridge opened their draw and so closed their bridge. It remained closed for about five years.

In 1841 the collection of tolls upon the Warren bridge

was renewed and the Charles-river bridge, having been purchased by the State for \$25,000 (Stat. 1841, Chap. 88), was reopened as a toll bridge. The toll system continued until Dec. 1, 1843, when both bridges were again made free. On the 1st of June, 1854 (Stat. 1854, Chap. 451), tolls were again established for the purpose of meeting the expense of rebuilding and repairing and for accumulating a maintenance fund, and they were again and finally discontinued on April 30, 1858.

In 1874 the care, management, and maintenance of these bridges was vested in the city of Boston. (Stat. 1874, Chap. 259.)

In 1880 the city of Boston was authorized to construct a new highway and bridge not exceeding 100 feet in width over Charles river, the Boston end to be between Beverly and Prince streets. (Stat. 1880, Chap. 125.) The permission thus given was not availed of.

By Stat. 1887, Chap. 398, the city of Boston was authorized to repair and relocate the Charles-river bridge and approaches or to build a new bridge at its option. By the same act the right, title, and interest of the Commonwealth in the bridge and its approaches and in the materials composing it were transferred to the city of Boston.

CHARLESTOWN BRIDGE, 1899.

By Stat. 1894, Chap. 548, which provided for the construction of the subway, the Boston Transit Commission was required to construct a bridge over Charles river between the Charles-river bridge and the Fitchburg Railroad bridge.

Soon after the organization of the commission, William Jackson, the city engineer, was selected as the chief engineer, and Mr. John E. Cheney as assistant engineer, for this purpose.

After a study of the traffic conditions and several public hearings, the commission reached the conclusion that a drawless bridge was desirable, but when the attempt was made to secure the requisite permits from the State and from the United States, it was found that at least two or three years would undoubtedly be consumed before these permits could be obtained, while, on the other hand, the effort might not ultimately prove successful. The idea of a drawless bridge was therefore reluctantly abandoned, but the height which would have been appropriate for such a bridge was retained, so that this bridge will not prove a barrier when the other bridges above it are raised and freed from draws.

The general plan of the bridge, after it was determined

upon, and before any of the work of construction was begun, had to be submitted to the Harbor and Land Commission and to the Secretary of War for approval. The license of the Harbor and Land Commission was issued 27th Nov., 1895, and that of the Secretary of War 27th Dec., of the same year.

The next six months were consumed in making, by means of borings, an exact study of the river bottom, in preparing construction plans, and in drawing up specifications.

On the 20th July, 1896, the contract for the construction of eight piers was awarded, and the actual work of building the bridge was begun on 15th Aug., 1896. This work has therefore taken a little over three years.

The total length of the bridge and approaches is 1,920 feet, of which 1,090 feet is over the water. It is a steel bridge on stone piers. Its width is 100 feet, which is divided into two sidewalks each 10 feet wide, two roadways each 29 feet wide, and a central space for street-car tracks 22 feet wide. From this central space team traffic is not excluded except in so far as the posts carrying the elevated-railroad tracks may operate as a barrier. The fixed spans are 85 feet each, and the draw span 240 feet, the draw resting on a central pier, on each side of which is a passage for vessels 50 feet wide. The height of the under side of the draw above mean high water is 23 feet. This draw weighs 1,200 tons, and rests on seventy solid steel wheels running on a circular track having a diameter of 54 feet.

The act of 1894 required the commission in constructing the bridge to have regard to its use for railway purposes. Three years later the Legislature (Acts 1897, chap. 500), authorized the Boston Elevated Railway Company to construct its tracks across the bridge.

The grade of the approaches to the bridge nowhere exceeds three per cent.

The chief contractors engaged upon the work have been Messrs. Woodbury & Leighton and Dennis F. O'Connell, who built the approaches to the bridge; Messrs. Perkins, White & Co., who built the piers and draw foundations; the A. and P. Roberts Company, which furnished the steel for eight spans of the superstructure and put it in place; the Pennsylvania Steel Company, which furnished and erected the steel for the two remaining spans and the draw, and Miller & Shaw, who installed the machinery for moving the draw.

No limit was placed upon the amount of money which the commission was authorized to expend for this bridge. The amount thus far paid out is about \$1,100,000. There are

still outstanding some claims which have not yet matured and also sundry large claims for damages for land taken and for changes of grade in the vicinity of the approaches to the bridge.

The act of 1894 authorized the Boston Transit Commission upon the completion of the new bridge to remove the Charles-river bridge. The license issued by the War Department of the U.S. made this removal compulsory. This work has been contracted for.

APPENDIX D.

**CANVASS OF BIDS FOR SOUTHERLY PORTION OF A SHELTER OF STEEL
AND CORRUGATED IRON, SOUTH OF CAUSEWAY STREET AND EAST
OF CANAL STREET, DEC. 13, 1898.**

BIDDERS AND ADDRESSES.	About 9,250 lbs. Steel Furnished by Contractor. About 6,250 lbs. Steel Furnished by Commission.		
	Amount.	Erection to be	
		Commenced.	Finished.
Edward Kendall & Sons, Cambridge, Mass.	\$1,480 00	Jan. 23, 1899	March 1, 1899
Boston Bridge Works, 70 Kilby street, Boston	1,440 00	Jan. 20, 1899	Feb. 10, 1899
New England Structural Company, 166 Devonshire street, Boston...	1,367 00	15 days from receipt of order	3 weeks from beginning of erection.

APPENDIX E.

CANVASS OF BIDS FOR NORTHERLY PORTION OF A SHELTER OF STEEL AND CORRUGATED IRON, SOUTH OF CAUSEWAY STREET AND EAST OF CANAL STREET, DEC. 22, 1898.

BIDDERS AND ADDRESSES.	Estimated weight 23,000 pounds, of which 10,900 pounds is furnished by the Commission @ 1.2 c. per lb.		Erection to be	
	Price per ton.	Totals.	Commenced.	Finished.
The King Bridge Co., Cleveland, Ohio.	\$210 00	\$2,284 20	Mar. 1, 1899	April 5, 1899
New Jersey Steel & Iron Co., Trenton, N.J.	205 00	2,226 70	Feb. 15, 1899	April 15, 1899
The Berlin Iron Bridge Co., E. Berlin, Conn.	200 00	2,169 20	Feb. 1, 1899	Feb. 25, 1899
Edge Moor Bridge Wks, Wilmington, Del.	192 00	2,077 20	Mar. 1, 1899	April 15, 1899
Edward Kendall & Sons, Cambridge, Mass.	185 00	1,996 70	Feb. 20, 1899	April 10, 1899
G.W. & F. Smith Iron Co., Boston, Mass. ...	180 00	1,939 20	Mar. 1, 1899	April 1, 1899
Boston Bridge Works, 70 Kilby st., Boston..	178 00	1,916 20	Feb. 15, 1899	April 1, 1899
New England Structural Co., 166 Devonshire st., Boston.....	171 00	1,835 70	Feb. 10, 1899	Mar. 10, 1899

APPENDIX F.

BIDS FOR PAINTING SHELTER AT NORTHERLY END OF SUBWAY WITH
TWO COATS OF RED LEAD PAINT SUPPLIED BY THE COMMISSION,
MARCH 6, 1899.

NAME AND ADDRESS OF BIDDER.	Amount bid.	Time required.
T. H. Halsted, 8 Allston place, Boston.....	\$124 50	10 days.
Edward J. McIntyre, 139 Tyler St., Boston.....	254 00	28 days of suitable weather.
Guy C. Emerson, 170 Summer St., Room 213, Boston	420 00	12 working days.

APPENDIX G.

REPORT ON BORINGS FOR THE EAST BOSTON TUNNEL.

BOSTON, Nov. 28, 1898.

MR. HOWARD A. CARSON, *Chief Engineer, Boston Transit Commission:*

DEAR SIR: I have completed the geological study of the borings made in connection with the proposed tunnel to East Boston to which you asked my attention. The results of this study are in a measure embodied in the three profiles of the harbor; but I submit here a more complete statement, giving it somewhat the form of a geological history of this part of Boston Harbor.

BED ROCK.

The normal bed rock for this part of the Boston basin is dark gray slate with an occasional dike of trap, as in the Somerville ledges. The only rock indicated by the few borings which have reached the bed rock is slate. The general line of strike of the slate for this part of the harbor, as shown by the ledges in Somerville and on Governor's island, and by the trend of the land masses, is northwest and southeast; and it is reasonable to suppose that the slate forms more or less distinct ridges which tend to conform in trend with the strike of the slate. One very pronounced ridge is indicated by Winter and Convent hills in Somerville, Bunker and Breed's hills in Charlestown, the southern part of East Boston, including the East District hill, Bird island flats, and Governor's island flats. Another and parallel ridge is represented by Spring, Prospect, and McLean Asylum hills in Somerville, and Copp's hill in Boston, while Beacon hill and Fort hill belong to a third ridge.

The slate bed rock was penetrated at a depth of 50 feet by the artesian well of the Boston Gas Works on Causeway street at the northwest end of Copp's hill; and the borings made under your direction on the line of the South Ferry reached bed rock under the west half of the tunnel (279, 280, 281, 282, etc.), somewhat in the line of Copp's hill, at depths of 70 to 80 feet below low tide; and it is probable that under the eastern half of the channel the bed rock surface sinks to a still greater depth, since it is there more nearly midway between the ridges outlined above. The borings on the two northern, or North Ferry, lines reached an approximately uniform depth of 90 feet below low tide, but being wholly free from the influence of Copp's hill, not one of them certainly reached bed rock. I have learned that borings made on either side of the elevators on the Grand Junction wharves, East Boston, to a depth of 100 feet below low water, failed to reach bed rock. Through the courtesy of Mr. H. R. Stanford, I have learned that of the borings for the new dry dock at the Navy Yard nine have reached the slate bed rock at depths varying from 39 to 98 feet below low water. At the office of the Harbor and Land Commissioners I have learned among other things that on the southeast side of Pier 4, South Boston, a boring of 118 feet below low water failed to reach bed rock; while, as is well known, the Anchorage shoal embraces a ledge of slate which before blasting was only 14 feet below low water, and farther in shore a half-tide slate ledge has been covered by the filling of the South Boston flats. In dredging the Upper Middle

shoal to a depth of 23 feet the slate bed rock has been extensively blasted. These meagre facts are sufficient to show that the bed rock surface in this vicinity is very uneven; but it is at least improbable that it is anywhere in the neighborhood of the proposed tunnel more than 125 to 150 feet below high tide level.

The principal streams, like the Charles and the Mystic, naturally conform in direction with the trend of the bed rock, and this consideration, together with the comparatively great depth of the bed-rock surface in the Back Bay district, as determined by artesian wells, 170 feet in one case, long ago convinced me that the lower course of the Charles river in preglacial times, when the land stood several hundred feet higher than now, was not in accordance with its present circuitous and crooked channel around the north end of Boston, but directly eastward across the Back Bay and Boston Neck. The waters of the Mystic may have reached the sea in preglacial times as now between Boston and East Boston; but it is quite as likely that the ancient bed-rock channel of the Mystic crosses East Boston in the vicinity of Central square. In that case every consideration would be favorable to a comparatively elevated bed-rock surface under the part of the harbor between Boston and East Boston.

BOWLDER CLAY.

Upon the bed rock rests at nearly all points the *boulder clay*, otherwise known as *till* and commonly also called *hard pan*. It is a heterogeneous mixture of clay with quartz flour, sand, gravel, and boulders which has been well compacted or hardened by time and especially by the long-continued pressure of the great ice sheet under which it was formed. The clay acts as a cement for the coarser materials; and the gravel and stones, on the other hand, give the mass, which is virtually a conglomerate, a good degree of firmness. In this part of the Boston basin the boulder clay occurs chiefly in the form of smoothly rounded hills or drumlins, which are elongated in the direction of glacial movement, northwest-southeast. Copp's hill, Fort hill, and all the hills of East Boston are drumlins. In the First District, east of Maverick square, is a very typical drumlin. Maverick square is near the southeast end of a low flat drumlin rising but a few feet above the sea; and north of Central square is a large double drumlin. The Man of War shoal has been proved by dredging to be boulder clay and probably marks the summit of a small and entirely submerged drumlin.

As a rule these special accumulations of boulder clay have a core, or nucleus, of rock, having been formed about more or less prominent ledges or rock elevations. In fact, the drumlins may be considered to owe their existence to the fact that the drift dragged along by the great ice sheet lodged against and upon the obstructing ledges. The dry-dock borings on the lee side of the Bunker hill drumlin show thicknesses of till ranging from 15 to 85 feet, and mostly above 60 feet, where filling hollows in the bed rock, and the artesian well at Marston's restaurant on Hanover street, on the lee side of Beacon hill, passed through 83 feet of boulder clay before penetrating the slate bed rock. The tunnel of the Boston, Revere Beach & Lynn Railroad in East Boston also proved a good depth of boulder clay.

Between the drumlins, as a rule, the boulder clay is spread rather thinly except where filling deep and narrow valleys; and it is frequently wanting, as in some of the western borings already noted of the South ferry profile, where the blue clay rests directly upon the bed rock. It is this principle which leads me to the conclusion that the boulder clay probably has no great thickness as a rule under this part of the harbor, and since a large proportion of the borings, especially in the two northern profiles, reached the boulder clay, we may fairly assume that if

they had gone a little (5 to 25 feet) deeper they would have struck the bed rock in most cases at least. Under the harbor on the lines of your borings and between the drumlins the surface of the bowlder clay has a fairly uniform depth of 80 to 90 feet below low tide, averaging a little lower in the northern profiles than in the southern profile. It must rise rather rapidly toward the Man of War shoal, where its original depth was not over 15 feet, and more gradually toward the Navy Yard, where the recent borings show depths of from 5 to 40 feet, but rarely exceeding 30 feet.

The drumlins have naturally gentle longitudinal slopes and steeper transverse or lateral slopes and partly through the moulding action of the ice and partly through the agency of either running or standing water the lateral slopes of the larger drumlins especially are steeper below and gentler above. This is well exemplified on the southwest side of the First District drumlin in East Boston and on the northeast side of Copp's hill; and still better by a comparison of the South Ferry profile where it crosses at a depth of 30 feet below low water the low southern extremity of the Copp's hill drumlin and the two North Ferry profiles, which show the almost abrupt lower northeastern slope of Copp's hill rising to within 10 or 15 feet of the surface.

The drumlins were formed under the southern margin of the ice sheet during the final recession or melting away of the ice; and in their relations to the ice movements they are somewhat analogous to sand bars in rivers, consisting of detritus which the current could not carry and being fashioned by the current.

BLUE CLAY.

Above the bowlder clay, or above the bed rock where the bowlder clay is wanting, comes in normal order the blue clay. This is a true glacial clay, a deposit of mud (largely ground up Somerville slate) from suspension in the waters of a temporary glacial lake which came into existence as the ice retreated from the area of Boston Harbor, the land being still much more elevated than at present. The general movement, or direction of recession, of the ice margin in this region was north-eastward; and after the ice had retreated from the main part of Boston Harbor the mouth of the harbor was still closed by ice, making of the harbor a fresh water glacial lake free from tidal current, frozen over during a large part of each year, and therefore very favorable in its tranquillity for the deposition of the fine blue clay. That the blue clay is not marine is proved by the entire absence of fossils and the fact that similar clay is not being deposited in the harbor at the present time except to a limited extent on the eel-grass flats. It is in the main a very tough, plastic clay, free from grit, but containing, as do all glacial clays, a large proportion of impalpably fine sand or quartz flour. There are, however, occasional thin layers and streaks of very fine sand, representing seasons when there was more motion in the water. The sandy clay recorded from quite a number of the borings is simply plastic blue clay, containing a larger proportion than usual of fine sand and quartz flour, but rarely enough to cause any appreciable deterioration of the clay. The angular fragments and grains of rock scattered irregularly here and there through the clay and most abundantly as a rule toward the bottom of the deposit are a very characteristic and significant feature of the clay. This material could not have been borne in suspension by the same currents that deposited the clay, but it was undoubtedly dropped by floating ice, — floe ice and icebergs.

Another convincing proof of the glacial origin of the blue clay is found in the fact that in a number of borings (86, 222, 223, 287, 288) on the west side of the harbor, and more or less in the lee of Copp's hill, the clay is divided, usually near the bottom, by a sheet of bowlder clay

from 10 to 25 feet in thickness; and the same thing has been observed in some of the recent borings at the Navy Yard. This can only mean that when the deposition of the clay began in this part of the harbor the margin of the ice sheet was still near by, so that a slight readvance of the ice spread a layer of boulder clay over a part of the blue clay; and when the ice again retreated this intrusive sheet of boulder clay was in its turn covered by a considerable thickness of the blue clay.

The borings show that the clay beds reach an extreme elevation of about five feet above high tide, which accords well with observations made in the clay pits of Everett and West Cambridge; and it extends to a depth under the middle of the channel in many of the borings of 80 to 90 feet below low tide; so that since the clay must have been deposited in perfectly horizontal even layers, and have covered the entire area to about the level of the highest point which it now attains, its maximum original thickness in this locality was over 100 feet.

This part of the harbor as it exists to-day is due to the erosion of the blue clay by the rivers and tidal currents. It has thus been removed across the main part of the channel to a quite uniform depth of 30 to 40 feet below low tide, and there remains consequently in general a thickness of 40 to 50 feet of clay, the extreme thickness being about 60 feet.

Since the blue clay is the principal deposit above the boulder clay, and the one in which the tunnel must be chiefly excavated, it demands special consideration. Careful mechanical analyses of the blue glacial clays in this region show that they invariably contain a large proportion of quartz flour, which detracts but slightly from its clayey qualities while adding to its value for brick making, etc., by tempering the clay. At its higher levels and everywhere above the low tide level the clay has been oxidized to a buff or yellow color; but elsewhere and almost everywhere under the harbor it is a typical blue or unoxidized clay. The fact that the yellow or oxidized clay, and also the oxidized boulder clay, is found in a few borings (such as 226, 259, 284, 286, 287, 288, 289, 290, 295) from 10 to 20 feet or more below low tide indicates that the glacial lake was drained and the deposit exposed to the air for a time before the land subsided to its present level relatively to the sea. Similar facts are observed in the Navy Yard borings, the oxidation extending to 30 feet below low water.

Whether oxidized or unoxidized, the clay is naturally of a very stiff, tough, and impervious character. I am satisfied that the boring samples, taken, as they must be, with the hole full of water, cannot adequately or fairly represent the clay as it exists in the ground as regards its firmness and ability to support itself; for its highly impervious character and the considerable weight which it bears must keep it comparatively dry, or free from any excess of water. The oxidation makes the clay, and also the boulder clay, harder and firmer by cementing the clay particles by iron oxide. As regards its imperviousness, it must be noted that the formation as a whole in its natural position must be more impervious or non-pervious to the overlying water of the harbor than filtration experiments with a representative series of samples would indicate, because the stratification of the clay must be strictly horizontal, and the highly impervious or non-pervious layers of plastic clay prevent the water from gaining access to the occasional relatively pervious sandy layers. Under the harbor, fortunately, the clay is at its best as regards uniformity of composition and structure, and it is practically impossible that there should be any oblique sandy layers which might serve as channels for the admission of water to the workings; while open joints or cracks are, of course, an impossibility under existing conditions. Toward the ends of the profiles some complications appear, such as the intruded layers of boulder clay, etc., but I have noted nothing that need be regarded as seriously detrimental to the tunnel project.

DETAILS OF THE BLUE CLAY.

On the South Ferry profile, beginning at the east end, we note a layer of very fine sand (quartz flour) near the bottom of borings 292 and 293; a merely local development of quartz flour; and this is true of all the so-called veins or pockets of sand. In boring 295 we have marked "plastic clay with stones," but the stones (dropped by floating ice) are hardly more abundant than in many borings where they are not specially indicated. The very fine clayey sand over the stiff blue clay in boring 212 is simply blue clay, with a larger proportion of quartz flour. In boring 288 the fine light sand underlying the boulder clay is rightly designated — a rather clean or non-clayey sand, indicating a local current too strong to permit the deposition of clay. On the other hand, the material under the boulder clay in boring 287 is best classed as a clay, although containing a large proportion of quartz flour and fine sand.

Passing to the North Ferry profiles, we have in borings 216, 217, 218, 219, 220, and 221, the blue clay passing upward, into, and alternating somewhat with, fine sand, suggesting the layer of sand overlying the clay bed in West Cambridge. In boring 223 a similar sand appears overlying boulder clay, and below the boulder clay comes six feet of clay, followed by nearly twenty feet of coarse sand and gravel. The non-occurrence of this washed and stratified material in borings 257, 259, and 261 suggests its deposition in a local subglacial body of water such as might result from the ice maintaining its arched form as it moved away from the Copp's hill drumlin. Such inclusions of washed material in drumlins are well known to geologists, and they normally occur, as in this case, only on the lee or southeast side of the drumlin. The section just described for boring 223 is repeated in boring 286, and below the stratified materials comes about 30 feet of boulder clay ending possibly in bed rock. Boring 222 appears to have passed through two layers of washed material, the boring ending in the lower one; and in boring 264 we have another very clear instance of blue clay interstratified in the boulder clay.

When the sea finally occupied this area the tidal currents rapidly scoured out the blue clay; and to some extent beach conditions were established along the sides of the drumlins. Thus may best be explained the layers of coarse sand and gravel over the blue clay in borings 213, 215, 224, 225, 258, 264, and 293. Where the boulder clay for a considerable distance from a given point was covered by the blue clay, as at the west end of the South Ferry profile, the beach deposit is necessarily wanting, as there is no available material from which gravel could be derived. An inspection of the original shore line shows that the North Ferry profiles are near the narrowest part of the harbor, and the stronger tidal currents thus determined may account for the fact that the blue clay has been cut out here about 10 feet deeper than on the South Ferry profile.

SILT.

"Silt" is used here as a general name for the recent deposits (including those now forming) which are of a fine or muddy character. Over the entire area covered by the borings the blue clay is covered normally by from two to five feet of soft black (carbonaceous) sandy mud, or, more properly, a fine muddy sand, which commonly contains shells or fragments of shells, and is thus strongly contrasted with the blue clay. Wherever the currents had excavated hollows in the surface of the blue clay these are filled with silt, which there attains an exceptional thickness, — 15 to 20 feet in some cases, as in borings 271, 272, 292, and 297. Other instances where this sandy silt has an exceptional thickness are best explained as due to the dredging of the silt and its use for filling.

In some instances the silt is less carbonaceous and passes as a fine sand, as in borings 212, 275, 293, and 298.

The silt is an entirely loose and uncompacted deposit which is easily moved or drifted about like sand on a beach by the action of the current; and hence areas from which it must once have been removed by dredging, as about the wharves, are now in general covered by it again so that it is, in fact, a nearly universal deposit in this part of the harbor. That the silt is very sensitive to variations in the force of the currents is shown by the fact that in a more sheltered area, like the angle between the Charles and Mystic rivers off the Navy Yard, it attains a much greater thickness—commonly 10 to 15 feet and a maximum of 25 feet. The fact that the deposition of this relatively coarse material between Boston and East Boston is almost at a standstill now is proof sufficient that the deposition of the blue clay belongs entirely to the past and to a somewhat remote past; for we have incontestible evidence that the deposition of this sandy silt began a long time ago and has witnessed a notable change in the relative levels of the land and sea. Innumerable borings and excavations in the low lands all about Boston and in the valleys of the Charles and Neponset rivers, etc., including your own works in the construction of the subway, the Metropolitan sewer, etc., have shown this highly fossiliferous silt, containing many shells no longer living in Boston Harbor, resting upon the blue clay and covered by a considerable thickness of peat, the peat being now largely below the high tide level and thus proving a subsidence of the land. This post-glacial subsidence, tending to deepen the harbor, has made the conditions increasingly favorable to the deposition of the silt. Hence we may conclude that when the tidal scour was actively eroding the blue clay to a depth of 40 or 50 feet the deposition of the silt was limited to the more sheltered bays, etc., but with the gradual subsidence of the land has come a slackening of the tidal movement, at least as regards its action on the bottom. The erosion of the blue clay is arrested and the deposition of the silt is possible to some extent even in the main channels.

GENERAL CONCLUSIONS.

For the sake of brevity and emphasis this section may be conveniently limited to a summary of the facts having a practical bearing upon the construction of the tunnel. The bed rock, so far as can be judged from evidence in hand, is a hard, firm, stable, and reliable formation; but its great depth under this part of the harbor deprives it, I suppose, of all influence upon your proposed operations. The case is essentially similar for the bowlder clay so far as the harbor proper is concerned; but at the ends of the profile it rises to the level of the tunnel and must be taken into account. It is in the main, at least so far as can be judged from the boring samples, a typical hard pan and can hardly fail to afford a satisfactory foundation for any construction you are contemplating. The only ground for apprehension is with regard to the inter-bedded layers of sand and gravel. These are for the most part too deep to have any influence upon your operations, the only exceptions disclosed by the borings being in borings 86, 222, and 223.

These bodies of washed material in the bowlder clay, rising only to the floor and not to the roof of the tunnel, are objectionable chiefly or only through the possible admission of water to the tunnel, especially during construction. The boring notes indicate some water from the sand and gravel layers in borings 86 and 223; and I venture to suggest that the use of a pump to determine the amount and persistence of the supply might be advisable. It is from the nature of the case extremely unlikely that any of these layers extend to the surface so as to afford channels for either rain water or sea water. Nor can we regard them individually as continuous over any considerable area; but they are

rather to be regarded as limited horizontal pockets of sand and gravel completely enclosed in the boulder clay—cisterns or reservoirs of water, but not capable of sustaining a strong continuous flow. The boulder clay itself should prove a highly impervious and stable deposit, and even more so in the zone of oxidation where you will chiefly encounter it than at greater depths.

The soft and unstable silt is fortunately wholly superficial, and of such slight thickness that it need not be taken into account, except in some of the borings on the South Ferry profile, where it attains a thickness of 15 to 20 feet. These are fortunately on the land, representing deep silting up in the sheltered bays that formerly existed on either side of the harbor, and especially on the Boston side.

It appears, then, that the blue clay is the formation in which the tunnel must be excavated for almost its entire length, and its characters therefore have for you a special practical interest and importance. Of the uniformity and imperviousness of the clay, it is unnecessary to speak further. It is distinctly an ancient formation, the last particle of the clay, it is probable, having been deposited at least ten thousand and possibly twenty thousand years ago. Under all the main part of the harbor, it has suffered erosion to the extent of 40 to 50 feet; that is, the clay now remaining has felt the long-continued pressure of that which has been removed. Time and pressure have undoubtedly done much to make the clay compact, hard, and dry.

Of course you have long ago noted that the fact that the harbor is about 10 feet deeper on the line of the two northern profiles than on that of the southern profile gives the latter, all other geological conditions being at least equally favorable, a distinct advantage as a route for the tunnel, and the high level pockets of sand and gravel are also wanting on this line; while on the other hand, the much greater depths of silt at either end of the south profile constitute the chief geological disadvantage of this line.

Yours respectfully,

W. O. CROSBY.



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